Air Safety Group
Report Nr 104

The Electronic Flight Bag Friend or Foe?

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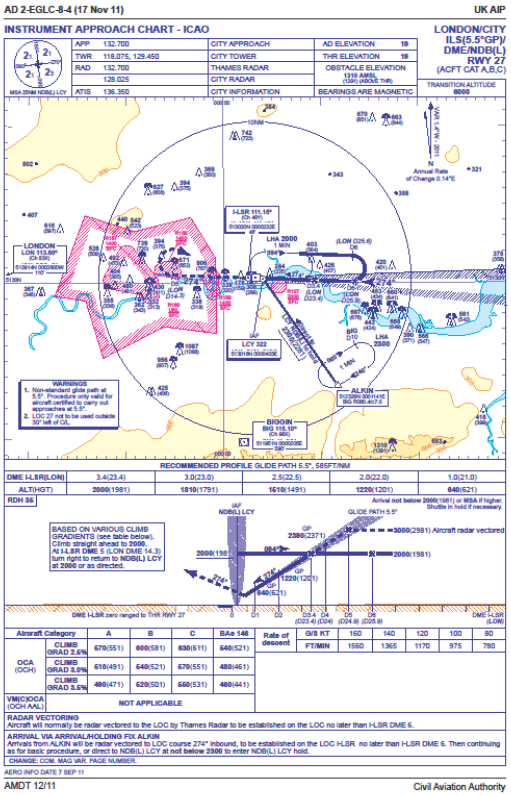
PREFACE

Digital technology in aviation is rapidly evolving. Most air operators hold an absolute reliance on automated systems both in the air and on the ground and most of us now accept the assumption that computers do a better job of things than we do. Computers, in aviation, are everywhere – in large form they are controlling aeroplanes and in small form are carried onto aeroplanes in the pockets of aircrew and passengers. This report discusses both the merits and the shortcomings of computers that are used by pilots on the flight deck during the course of their daily duties and the pendulum of advantages versus dangers that they can bring and have brought.

The Electronic Flight Bag or EFB was conceived out of a necessity to reduce costs by improving efficiency. In its simplest form the EFB is a method of replacing aircrew amenities that were once provided on paper by storing them in a mobile computer or a computer that is built into the aeroplane. There are numerous advantages to this, for example a library of manuals that must be carried on-board may weigh up to 50 kgs and it costs money by hauling them around the skies. Also, aircrew no longer have to fly with missing or out of date documentation. Gradually as air operators realised the benefits that the EFB was delivering they also recognised its potential, so it evolved into a tool that now plays a major role in flight safety by the information that it delivers and the manner in which the human uses it and its ability to connect with on-board avionics.

So what else can the EFB do? Here are a few examples:

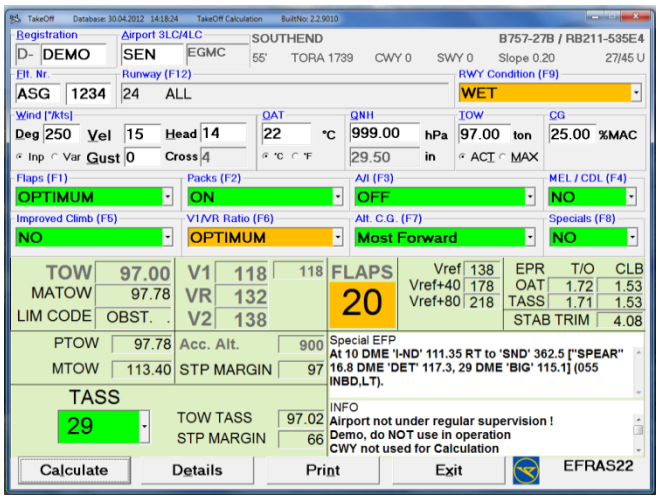
- Navigation and Instrument Approach chart display like the one below; or


AD 2-EGLC-8-4 (17 Nov 11)
UK AIP
INSTRUMENT APPROACH CHART - ICAO
LONDON/CITY
ILS(5.5°GP)/
DME/NDB(L)
RWY 27
(ACFT CAT A,B,C)
APP 132.700
TWR 118.075, 129.450
RAD 132.700
128.025
ATIS 136.350
CITY APPROACH
CITY TOWER
THAMES RADAR
CITY RADAR
CITY INFORMATION
AD ELEVATION 19
THR ELEVATION 19
OBSTACLE ELEVATION
1310 AMSL
(1291) ABOVE THR
BEARINGS ARE MAGNETIC
TRANSITION ALTITUDE
6000
LONDON
LCY 322
LHA 2000
ALKIN
BIGGIN
WARNINGS
1. Non-standard glide path at 5.5°. Procedure only valid for aircraft certified to carry out approaches at 5.5°.
2. LOC 27 not to be used outside 30° left of GL.
RECOMMENDED PROFILE GLIDE PATH 5.5°, 585FT/NM
DME I-LSR(LONG)
ALT/HGT)
RDH 36
BASED ON VARIOUS CLIMB GRADIENTS (see table below). Climb straight ahead to 2000. At I-LSR DME 5 (LON DME 14.3) turn right to return to NDB(L) LCY at 2000 or as directed.
Aircraft Category
A
B
C
BAe 146
Rate of descent
G/S KT
FT/MIN
OCA (OCH)
CLIMB GRAD 2.6%
CLIMB GRAD 3.0%
CLIMB GRAD 3.5%
VM(C)(OCA (OCH AAL)
NOT APPLICABLE
RADAR VECTORING
Aircraft will normally be radar vectored to the LOC by Thames Radar to be established on the LOC no later than I-LSR DME 6.
ARRIVAL VIA ARRIVAL/HOLDING FIX ALKIN
Arrivals from ALKIN will be radar vectored to LOC course 274° inbound, to be established on the LOC I-LSR no later than I-LSR DME 6. Then continuing as for basic procedure, or direct to NDB(L) LCY at not below 2500 to enter NDB(L) LCY hold.
CHANGE: COM, MAG VAR, PAGE NUMBER.
AERO INFO DATE 7 SEP 11
AMDT 12/11
Civil Aviation Authority

- Libraries of operational manuals like the Minimum Equipment List or the Aeroplane Flight Manual;

- Forms that can be completed using the EFB like a voyage report or journey log or Air Safety Reports;

Additionally the EFB can host aeroplane performance and weight and balance software calculators which again replace tabulated paper charts but also provide more accurate take off performance information (V speeds) because they use actual data rather that data which is rounded to the nearest 100 kgs to make life simpler for humans. Here is an example of a performance calculator for a B757 departing Southend airport RWY24.



There are many other uses including cabin surveillance, communications and Air Traffic Control software like Automatic Dependent Surveillance Broadcast.

The advantages and benefits of using a fleet wide EFB system are compelling and often justify the investment. Here is another example:

- Tracking - rapid dissemination and promulgation of vital information to aircrews is an important safety feature. Tracking allows flight crew managers on the ground to see when a crew member has opened an important flight crew notice and obtain a declaration that he has read and understood its contents.

So the principle of the EFB is a sound idea that offers the operator gains in air safety and efficiency and operating cost reductions. But for every pro there is a con and whilst the pros are attractive the cons can quickly upset the equilibrium by turning foresight into failure or at worse; disaster.

In Europe and the USA the EFB is the subject of regulation with regards to what type of equipment and software can and cannot be installed and how it should be administered. Operators must apply for permission to use an EFB system on their aeroplanes and the submission must detail the methods of compliance which include policy, administration, hardware and crew training. EFB regulations are comprehensive yet despite this the EFB has contributed to one fatal accident and many serious incidents involving passenger aeroplanes all over the world. Most of the serious incidents were caused by human data entry error where glaringly obvious data entry errors were made by intelligent and

experienced aircrew. And not only did the data entry errors go unnoticed but the resulting computed results were deemed accurate; unquestioned by both pilots even though, in hindsight, they would have doubted their veracity.

As if the ability of a humble mobile computer to hoodwink an intelligent uses isn't enough to worry about, there is also the risk that it can turn into a lethal incendiary device where a thermal runaway of the lithium-ion batteries can spontaneously erupt into a fire of extreme temperatures the extinguishing of which can prove tricky, especially as Lithium (an alkali metal) reacts with air and water. Modern 'tablet' style computers, like the iPad, have their batteries embedded within the casing, making them inaccessible to the user and therefore difficult to extinguish should they catch fire. Lithium battery fires are current news at the moment and have caused the grounding of the entire B787 fleet for the foreseeable future.

This report is intended to highlight concerns with regards to the safety threats that the EFB has and can raise, in its short time span of operational use and makes recommendations with regards to changes and additions to regulatory requirements, that will go some way to improving its safety.

R Nigel Johnstone

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ABBREVIATIONS / GLOSSARY

AAC	Aeronautical Administrative Communications defined by ICAO as communications used by aeronautical operating agencies related to the business aspects of operating their flights and transport services.
AAIB	Air Accidents Investigation Branch
ACARS	Aircraft Communications Addressing and Reporting System
ADC	Air Data Computer
ADS-B	Automatic Dependent Surveillance - Broadcast
AFM	Aeroplane Flight Manual
AIRAC	Aeronautical Information Regulation and Control cycle (ICAO)
AOC	Aircraft Operational Communications - (Airline terminology same as AAC)
APU	Auxiliary Power Unit
ARINC	Aeronautical Radio, Inc.
ARM	Advanced RISC Machine
ARTCC	Air Route Traffic Control Centre
ASR	Air Safety Report
ASRS	Air Safety Reporting System
ATC	Air Traffic Control
ATN	Aeronautical Telecommunication Network
ATOM	Actual Take-Off Mass
ATOW	Actual Take-Off Weight
BLT	Boeing Laptop Tool
CD-ROM	Compact Disk - Read Only Memory
CDU	Control Display Unit (FMC I/O panel)
CG	Centre of Gravity
COTS	Commercial Off The Shelf
CPDLC	Controller Pilot Data Link Communications
CRM	Crew Resource Management
D-ATIS	Digital Automatic Terminal Information Service
DPI	Digital Performance Information
DVD	Digital Versatile/Video Disk
EASA	European Air Safety Agency
ECAM	Electronic Centralised Aircraft Monitor
ECL	Electronic Checklist
EFB	Electronic Flight Bag
EGPWS	Enhanced Ground Proximity Warning System
EICAS	Engine Indication and Crew Alerting System
ETOPS	Extended Twin-Engine Operations
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAR	Federal Aviation Regulation
FLIP	Flight Information Publication
FMC	Flight Management Computer
FMS	Flight Management System
FTP	File Transfer Protocol
g	Gravitational Constant
GA	General Aviation
GB	Gigabyte (billion bytes)
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GUI	Graphical User Interface
HMI	Human Machine Interface
HUD	Heads Up Display
I/O	Input / Output
IAP	Instrument Approach Procedure/Plate
ICAO	International Civil Aviation Organisation
ICT	Information and Communications Technology
IDE	Integrated Digital Environment
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IP	Internet Protocol
IR	Infrared
IRS	Inertial Reference System
IT	Information Technology
JOEB	Joint Operations Evaluation Board
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LHS	Left Hand Seat
MB	Megabyte (million bytes)
MCDU	Multifunction Central Display Unit
MEL	Minimum Equipment List
MFD	Multi-Function Display
MHz	Mega-Hertz (million hertz)
mm	Millimetre

MOR	Mandatory Occurrence Report
MSP	Minneapolis St Paul
MTC	Mobile Tablet Computer
NAA	National Aviation Authority
NDB	Non-Directional Beacon
NM	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NORDO	No Radio Communications
NOTAM	Notices To Airmen
NTSB	National Transportation Safety Board
NWS	National Weather Service
OPS	Operations
OPT	On-board Performance Tool
OS or O/S	Operating System
PANS-OPS	Procedures for Air Navigation Services Operations (see ICAO Doc 8168)
PCMCIA	Personal Computer Memory Card International Association (PC Card)
PDA	Personal Data Assistant
PDF	Portable Document Format (Acrobat Reader)
PED	Portable Electronic Device
PF	Pilot Flying
PIC	Pilot In Command
PM	Pilot Monitoring
PPI	Pixels Per Inch (usually depicted in lower case—ppi)
RAM	Random Access Memory
RHS	Right Hand Seat
RISC	Reduced Instruction Set Computing
RMS	Root Mean Square
ROM	Read Only Memory
SA	Situational Awareness
SATCOM	Satellite Communications
SCAP	Standard Computerised Aeroplane Performance
SID	Standard Instrument Departure
SOP	Standard Operating Procedure
STARs	Standard Arrivals
STC	Supplemental Type Certificate
TA	Traffic Advisory
TC	Type Certificate
TCAS	Traffic Alert and Collision Avoidance System
TCDS	Type Certificate Data Sheet
TERPS	Terminal Instrument Procedures
USB	Universal Serial Bus
VDL-3	VHF Digital Link Mode-3
VFR	Visual Flight Rules
VHF	Very High Frequency (30 - 300 MHz)
VORTAC	VHF Omni-directional Range/Tactical Air Navigation (navigational aid)
VPN	virtual private network
XML	Extensible Mark-up Language

REPORT CONVENTIONS

This document is gender neutral, occurrences of the word *'his' or 'he' or 'himself'* should be construed as both male and female gender.

This is an electronic publication which contains hyperlinks to online documents; these will only work if the document is rendered by a computer that is connected to the internet.

Both the terms *"weight"* and *"mass"* are used in this document and should be construed as having identical meaning. The use of these terms is not defined or mandated by ICAO, but some aviation authorities express a preference of using one over the other and encourage operators to follow suit.

"Our remedies oft in ourselves do lie,
Which we ascribe to Heaven."

Shakespeare 'As You Like It' 1623

"Took my chances on a big jet plane,
Never let them tell you that they're all the same."

Led Zeppelin IV 1971

INTRODUCTION

Information technology has made great advances throughout industry. In the early years the adaptation of automation technology (computers) in aviation purely concerned the operation of the aeroplane and its components. Nowadays the creation of portable computers has encouraged operators and manufactures to devise ways of using this technology to improve operational efficiency, reduce administrative burdens and direct operational costs, one area of which is the continued maintenance of the vast number of books and paper forms that are required to allow commercial airliners to fly.

The introduction of portable computers onto the flight deck enabled the operators' desire to become "paperless" though the elimination of paper on the flight deck. However this is not always feasible, so more commonly the EFB achieves a 'less paper' principle. For example the rendering of a navigation chart with a representative fraction of 1:2,500,000 on a computer screen measuring 10.6" diagonally makes purposeful use impossible. Nevertheless many pilots find these impracticalities forced upon them, mainly for reasons of saving of cost.

Pilots still carry large quantities of paper onto the aeroplane, which augment the flight operational libraries that permanently reside on the flight deck. Most if not all of the printed information and forms already exist in an electronic format elsewhere.

Aeroplanes and aircrew that are not equipped with EFB's must carry the documentation required to fly in a paper format, i.e. a book; these can include the operations library (at least 6 weighty tomes), checklists, instrument approach plates, enroute navigation charts and so forth. The currency of these documents requires constant updating by manual labour and this necessitates a small workforce to administer these processes and logistics. The larger the fleet the larger the workforce required to maintain the upkeep of the ships and aircrew documentation. The money spent on developing, producing, distributing and maintaining this documentation in a paper format varies from system to system, but in general, is quite high. Additionally, in most cases the documents are initially created in an electronic medium and much of the cost is in converting electronically produced information into a paper medium.

The EFB can replace manual updating, dissemination and logistical processes and alleviate many of the problems associated with them. Though the cost of introduction of an EFB system is high, the annual running costs are low, when compared to paper based systems; therefore the payoff can be achieved quickly. In an attempt to minimise the high costs associated with the administration of paper based document systems for their pilots, many major commercial airlines have begun to research the suitability of an in-house EFB system.

The removal of paper based libraries from the flight deck is facilitated by storage of the information in digital format on a computer. The computer can be a portable type or one that is fixed by attachment to the aeroplane. The advantages that rendering of documentation on an EFB can bring, is both numerous and obvious; for example an aeroplane need never leave the ground with out of date documentation or important unread information due to the automated electronic dissemination advantages that an EFB brings. Furthermore if a computer is to be used to render documentation to the flight and cabin crew, then why not use it to also calculate performance and weight and balance data?

This is where a possible compromise of air safety exists, sometimes with fatal consequences. The EFB system is a cocktail of contrasts of augmenting air safety on one hand, and reducing air safety on the other. With the recent proliferation of cheap mobile computers having disparate operating systems, some of which are not compatible with manufacturers' software, a significant hazard could soon be encountered, moreover the ease with which these types of devices can be adapted for use as an EFB could soon overwhelm the regulators diminishing their oversight and control.

1 WHAT IS AN ELECTRONIC FLIGHT BAG

EFBs are electronic information management devices that help pilots perform flight management tasks more easily and efficiently with less, or in some cases, no paper.

Traditionally all documentation and information available to flight crew for use on the flight deck has been in paper format. Much of this information is now available in electronic format.

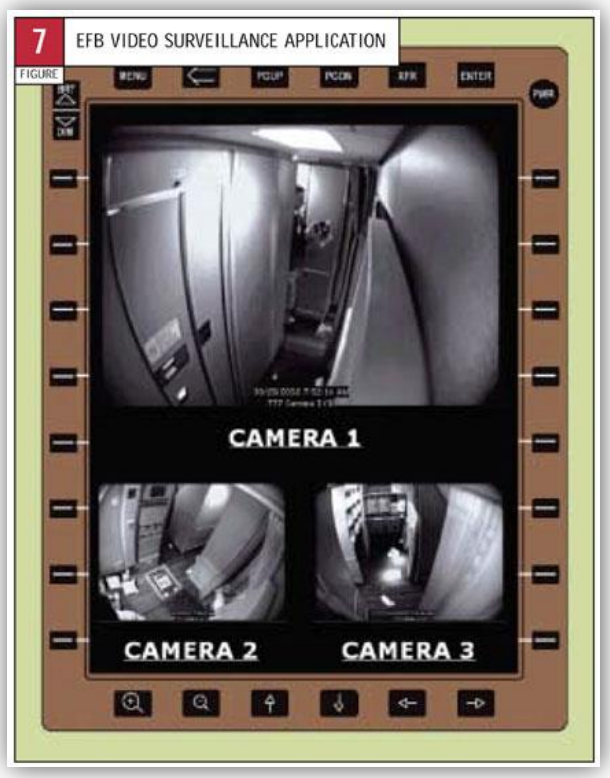
EFB devices can render a variety of aviation data, for example, checklists, navigation charts, flight operations libraries of manuals like the AFM, MEL, operations manuals from part A to C and the Cabin Crew SEP manual.

EFB devices can perform calculations of performance data, for example take-off and landing performance data, weight and balance C of G computations and fuel reckoning. In the past these functions were traditionally accomplished by aircrew using paper references and raw brain power or were based on data provided to the flight crew by an airline's "flight dispatch" crew.

When used correctly, EFB's can advance and augment air safety, improve flight operational efficiency and reduce fixed and direct operating costs though greater computational accuracy in terms of CG and precise engine power requirements.

Physically EFB's come in various shapes and sizes, from laptop, tablet and note book portable computers devices to small server type computers that are housed within electronic equipment compartments on the aeroplane or attached to the airframe in a suitable location on the flight deck.

The EFB may also provide non paper supported tasks such as video surveillance display.



A Class 3 EFB with interior surveillance mode selected.

2 EFB VARIOUS TYPES

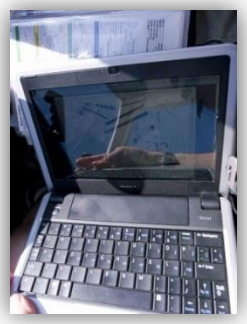
EFB's come in three types which are classified as follows:

2.1 Class 1

Class 1 EFB Systems do not require NAA airworthiness approval. They can be used both on the ground and during non-critical stages of flight (see EU-OPS Subpart D 1.192 h), but must be stowed for take-off and landing. They are limited to providing supplemental information only and cannot replace any required system or equipment.

The hardware is:

- Generally COTS - based computer systems adapted for aircraft operational use;
- A portable device;
- Only connected to aircraft power through a certified power source;
- Not attached to an aircraft mounting device, hence no airworthiness approval requirement;
- Considered, for regulatory purposes, to be a controlled PED;
- Normally without aircraft data connectivity except under specific conditions.



A Class 1 EFB is not considered to be part of the certified aircraft configuration, i.e. not in the aircraft type design nor installed by a change to the Type design nor added by a Supplemental Type Certificate. Therefore, Class 1 EFB systems do not require airworthiness approval. EFB Class 1 systems may run software in both the classification type A and type B.

2.2 Class 2

Note the location of the EFB in relation to the DV window.

Class 2 EFB Systems require a limited NAA airworthiness approval. Although considered to be a portable electronic device, an entry in the Aircraft Technical Log is required to remove a Class 2 EFB from the aircraft. It can be connected to aircraft power and to the aircraft's data link port and can exchange data with aircraft systems, enabling it to make interactive performance calculations. It can be used to compute weight and balance information as well as take-off and landing speeds, and to display flight critical pre-composed data, such as navigation charts. Since it is not necessarily stowed for take-off and landing, pilots can use it to display departure, arrival, and approach charts.

The hardware is:

- Generally COTS based computer systems adapted for aircraft operational use (e.g., laptop, tablet PC) considered as a controlled PED;
- Connected as required to aircraft power through a certified power source;
- Attached, when in, use to an aircraft mounting device, such as an arm-mount, kneeboard, cradle or docking station, allowing use during all phases of flight;
- Connectable to aircraft power and data connectable (e.g. a remote display unit, cursor control device, keyboard etc.);
- capable of quick-disconnection for egress if necessary
- considered for regulatory purposes to be a 'controlled PED'
- allowed to be connected to aircraft avionics

Some elements of a Class 2 EFB system require an airworthiness approval. The approval is limited in scope to the aircraft mounting device, crashworthiness, data connectivity, EFB power connection and the installed resources, if any. The COTS based computer system hosting the EFB software applications and the Operating System is considered to be a controlled PED and does not require an airworthiness approval.

Note: A Class 2 EFB or a part of a Class 2 EFB system is considered portable if it is not part of the certified aircraft configuration, i.e. not in the aircraft Type design nor installed by a change to the Type Certificate or a STC. A portable EFB system is considered as a controlled PED. However, a part of the EFB system is considered installed if it is part of the certified aircraft configuration, i.e. in the aircraft type design or installed by a change to the Type Certificate or a STC.

2.3 Class 3

Class 3 EFB Systems are installed aircraft equipment requiring an STC or a certification design approval as well as NAA Airworthiness approval. Paper charts may not be required. Depending on the model, it may be connected to the GPS or FMS for navigation purposes and it may also be able to combine GPS position with the locations and speed vectors of other aircraft and graphical weather information into a single, detailed moving map display. Its detailed database can also provide obstacle and terrain warnings.

The NAA approval will take particular account of:

- The integrity of the EFB hardware installation including its data storage function, the display, the keyboard and the power switching process including hardware and software qualification;
- The issues arising from the human-machine interface.

2.4 Hardware

As described above Class 1 and Class 2 EFB computers are COTS that have been adapted to suit the flight operational task and environment.

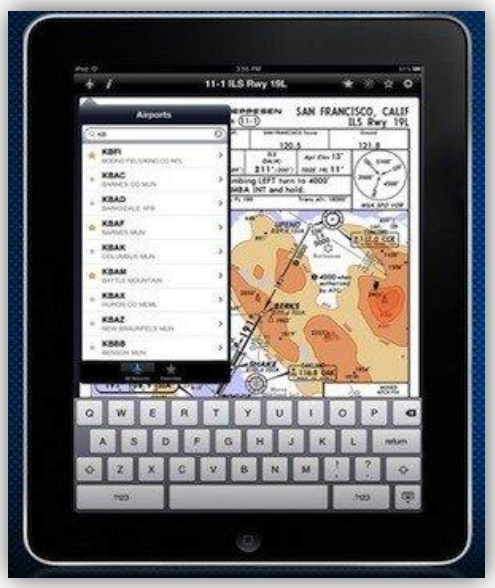
Class 1 EFBs are mainly portable laptop or notebook personal computers. In some cases tablet computers (no keyboard) may be used or a combination of tablet and notebook computer.

Laptop/Notebook Computer

Tablet Computer

Both computers utilise X86 processors and run DOS and Windows based operating systems.

2.4.1 Tablet Computers (ARM Processors) Mobile Computing



The iPad was first launched in 2010 and in a little over 2 years 55 million units have been sold (source Times Business iPad sales) . The iPad is a tablet computer with a new operating system (IOS) that has revolutionised the way in which the user interacts with the device. IOS is a very intuitive and stable platform and easy to use for any level of user proficiency.

Modern mobile computing devices (like the iPad) use ARM microprocessor chips. Their reduced instruction set lessens the power required by the processor thus making mobile computing, using small lithium batteries, possible. The iPad has a built-in 42.5 watt-hour rechargeable lithium-polymer battery. ARM processors can be found in many smart phones and PEDs. The key to the success of the iPad is the interaction of the user with the software applications using a touch sensitive screen so the conventional use of a keyboard and mouse is negated. This makes this type of tablet device attractive for use in confined environments, like the flight deck, as a finger is all that is required to operate the various software applications. Furthermore its dimensions, 9.5”x7.3”, allows it to fit conveniently into a pilots flight bag (they still carry one!). The dimensions of the screen are close to the size of an instrument approach chart (IAC).

There many different types of MTC of which the iPad is by far the most popular. Currently, none of these machines utilise and execute a DOS type operating system so that the software that they run will not operate on a computer that uses a windows operating system, i.e. the majority of office PC’s and laptop computers.

Leading aircraft manufactures supply performance and weight and balance data (SCAP and AFM DPI) and applications (calculators) that are produced using the FORTRAN programming language which is compatible with DOS type operating systems but incompatible with MTC operating systems like IOS and Android, for example.

3 SOFTWARE

Software that is stored and executed by an EFB computer is classified as Type A, Type B and Type C.

3.1 Type A

Type A applications include pre-composed, fixed presentations of data currently presented in paper format. Type A applications require an operational approval by NAA but they do not require an airworthiness approval.

Typical examples of Type A applications are:

- A Document Browser rendering non-interactive documents in a pre-composed format such as :
    - The Aircraft Noise Certificate;
    - The Air Operator Certificate;
    - The Third Party Liability Insurance Certificate.
- Operations manuals (OM Part A - C) and additional information and forms - Journey Logs, ASR etc.;
- The MEL and CDL;
- Aircraft Flight Manual;
- The aircraft Technical Log other than the Sector Record pages;
- ATS Flight Plan;
- NOTAMs and AIS briefing information;
- Meteorological information;
- Pre-computed mass and balance information;
- Notification of special categories of passenger;
- Notification of special loads and any other information that might be required such as passenger and cargo manifests.

Other information within the operator’s aircraft library such as:

- Airport diversion policy guidance, including a list of Special Designated Airports;
- Maintenance Manuals;
- Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods (ICAO Doc 948 1- AN/928);

- Aircraft parts manuals;
- Service bulletins / published Airworthiness Directives, etc.;
- Current fuel prices at various airports.

3.2 Type B

Type B applications include dynamic, interactive applications that can manipulate data and its presentation. Type B applications require operational approval by the operator's NAA but do not require an airworthiness approval. Type B software can be hosted on any of the hardware classes listed above.

Typical examples of Type B Software Applications are:

- A document Browser displaying documents that are interactive, or not in a pre-composed format that may be driven by sensed aircraft parameters;
- Operations manuals, for example OM Part A - C including the MEL and CDL and additional information and forms;
- The AFM;
- The Operational Flight Plan;
- The Sector Record pages of the aircraft Technical Log;
- Meteorological information with graphical interpretation;
- Electronic aeronautical chart applications including en-route, area, approach, and airport surface maps including panning, zooming, scrolling, and rotation, centring and page turning but without display of aircraft/own-ship position;
- Aircraft performance calculators (applications that use algorithmic data or calculate using software algorithms) that provide limiting masses, distances, take-off speeds (V speeds), landing, missed approach data and in some case power settings, including reduced take-off thrust settings;
- Mass and balance calculators that are used to establish the mass and centre of gravity of the aircraft and to determine the load and its distribution so that the mass and balance limits of the aircraft are not exceeded;
- Data acquisition applications that communicate with ground based servers, using either the internet or installed aeroplane communications, that can form part of a post flight data reconciliation service for uses such as spare parts and budget management, spares/inventory control, unscheduled maintenance planning etc;
- Cabin-mounted video and aircraft exterior surveillance camera displays;
- Electronic aeronautical chart applications with a symbol indicating aircraft / own-ship position that is displayed during any phase of flight (this functionality will need to follow a normal airworthiness approval process).

There is no limit on the hosting of type B applications on a Class 1 EFB, but in the case of electronic aeronautical chart applications, their normal use on Class 1 hardware is prohibited during critical phases of flight (EU-OPS 1.192 FAR 121-542), unless the Class 1 EFB is a knee board system. HMI considerations are applicable in this case.

3.3 Type C

Type C software is EFB bespoke software that has been deemed ineligible for classification as Type A or Type B. Type C applications can only be hosted on a Class 3 device and they require both an operational and an airworthiness approval.

Type C software applications are those for which the functional hazard assessment has been determined to be capable of affecting and influencing air safety.

Typical examples of Type C applications are:

- Applications that render information which can be tactically used by the flight crew to check or control the aircraft trajectory, either to follow the intended navigation route or to avoid adverse weather, obstacles or other traffic, in flight or on ground.

- Applications that render information which can be directly used by the flight crew to assess the real-time status of aeroplane critical and essential systems, as a replacement for existing installed avionics and allow management of these systems following a failure;

- Applications that are a primary means of communication with air traffic services, for example, ADS B, where the flight path of the aircraft is authorised, directed or controlled (ADS B see definitions 11.1);

4 CONNECTIVITY

4.1 Connectivity with External Ground Based Resources and Data Transfer Devices

An EFB device that can communicate with external ground based file servers benefits from ease of access to current data and real time data exchanges.

When using a Class 1 EFB on the ground, for example, during pre-flight briefing, it can acquire data using the internet through industry standard I/O ports. Typical examples of these are listed below:

Laptop I/O ports showing RJ45 USB3 SD Card

Removable Flash Memory Card or memory Stick

Laptop docking station *(When docked an EFB can connect with the internet and/or an intranet or company IT Network)*

SD Card

Through the use of these types of data transfer media the EFB can acquire active operational data and operational reference material and documentation. Data acquired by the EFB will be stored on its internal hard drive.

Examples of the type of data that can be acquired are:

Operational Data - Active	
OFP	Operational Flight Plan
Route Brief	NOTAMS, MET Charts etc.
Navigation Trip Kit	Charts IAPs pertinent to the route to be flown
Performance	TOF and LDG Performance information
Operational Data - Reference and Non Operational	
Operational Data - Reference	
Ops Library	Manuals Part A to C
MEL	
Administration Documentation	Forms etc.
Personal email	Company email

Strictly speaking this paragraph applies to Class 1 devices though in some cases it may apply to portable Class 2 devices that do not solely reside on the flight deck, for example, the latest tablet computers like the iPad.

4.2 Internet and Intranet

The Internet is a global system of interconnected computer networks that use the standard Internet protocol suite, referred to as TCP/IP that facilitates the transfer of data from one computer to another. It is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies. The Internet carries information and document resources and services via the World Wide Web (WWW) and has the infrastructure to support email.

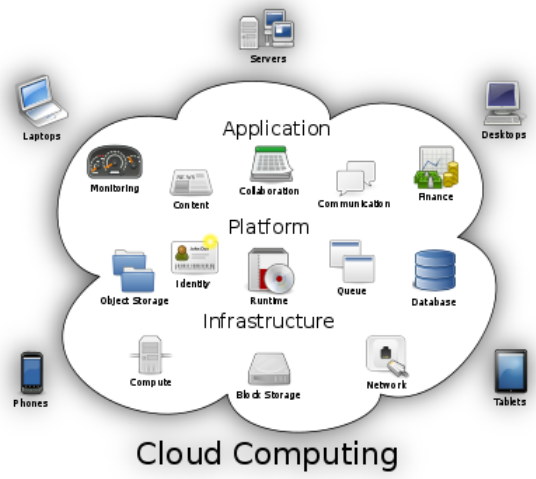
An intranet is a computer network that uses Internet Protocol technology to share information, operational systems, or computing services within an organisation. An intranet may host multiple private websites and constitute an important component and focal point of internal communication and collaboration. Any of the well-known Internet protocols may be found in an intranet, such as HTTP (web services), SMTP (e-mail), and FTP.

An intranet is a private and secure extension of the Internet confined to an individual operator.

In many organisations, intranets are protected from unauthorised external access by means of a network gateway and firewall. For smaller companies, intranets may be created simply by using private IP address ranges where the intranet can only be directly accessed from a computer within the local network; however, an operator's intranet can be accessed by an off-site or down route EFB by using a VPN, or by other access methods, requiring user authentication and encryption.

4.3 Cloud Computing

Cloud computing refers to the delivery of computing and storage capacity as a service to a heterogeneous community of end-recipients. The name ‘cloud’ is a metaphor for the internet which provides data abstraction operations from complex infrastructures.



Cloud computing enables users to acquire data and execute programs that can compute and provide the results over a network. End users access cloud based applications through a web browser or a light weight desktop or mobile software application (now referred to as an ‘app’) while the business end software and data are stored on servers at a remote location. At the foundation of cloud computing is the broader concept of converged infrastructure and shared services.

4.4 GateLink

Gatelink is a term used to describe a facility that provides a communications link using Internet Protocols (IP) to provide data services between a parked aeroplane and the ground IP network infrastructure. Communications between the aeroplane and the Gatelink facility are often enabled via a WI-FI or wireless communications link but can also be provided by a physical connection into the aeroplane. Gatelink provides a connection between the airport and the on-board aeroplane network. Gatelink enables operators to communicate in a secure manner with the aeroplane network and appliances using data encryption complaint with the ARINC 822 protocol.

5 REGULATION

In Europe EFBs are regulated by NAAs and by the EASA Joint Operational Evaluation Board, also known as the Operational Evaluation Board.

5.1 Approval

Prior to approving additional electronic devices to form part of an AOC operation, it will be necessary to demonstrate that, when fitted to an aircraft, no additional hazards will result.

5.1.1 Class 1

Approval is sought from the assigned Flight Operations Inspector. Evidence must be produced that no interference or harmful effects will be encountered, during flying operations, by the use of an EFB from the following:

- EMI Demonstrations
  If the Class 1 EFB device is to remain powered (including being in stand-by mode) during take-off and landing, further EMI demonstrations (laboratory, ground or flight test) are required to provide greater assurance of non-interference and compatibility.

- Batteries
  During the procurement of Class 1 EFB devices, special consideration should be given to the intended use and maintenance of devices incorporating lithium batteries.

  Note: As a minimum specification, the lithium battery incorporated within the EFB device should have been tested to Underwriters Laboratory Inc (UL) Standard for Safety for Lithium Batteries reference UL 1642.

  Scope of UL 1642

- *These requirements cover primary (non-rechargeable) and secondary (rechargeable) lithium batteries for use as power sources in products. These batteries contain metallic lithium, or a lithium alloy, or a lithium ion, and may consist of a single electrochemical cell or two or more cells connected in series, parallel, or both, that convert chemical energy into electrical energy by an irreversible or reversible chemical reaction.*

- *These requirements cover lithium batteries intended for use in technician-replaceable or user-replaceable applications.*

- *These requirements are intended to reduce the risk of fire or explosion when lithium batteries are used in a product. The final acceptability of these batteries is dependent on their use in a complete product that complies with the requirements applicable to such product.*

- *These requirements are also intended to reduce the risk of injury to persons due to fire or explosion when user-replaceable lithium batteries are removed from a product and discarded.*

- *These requirements cover technician-replaceable lithium batteries that contain 5.0 g (0.18 ounce) or less of metallic lithium. A battery containing more than 5.0 g of lithium is judged on the basis of compliance with the requirements in this standard, insofar as they are applicable and further examination and test to determine whether the battery is acceptable for its intended uses.*

- *These requirements cover user-replaceable lithium batteries that contain 4.0 g (0.13 ounce) or less of metallic lithium with not more than 1.0 g (0.04 ounce) of metallic lithium in each electrochemical cell. A battery containing more than 4.0 g or a cell containing more than 1.0 g lithium may require further examination and test to determine whether the cells or batteries are acceptable for their intended uses.*

- *These requirements do not cover the toxicity risk that may result from the ingestion of a lithium battery or its contents, nor the risk of injury to persons that may occur if a battery is cut open to provide access to the metallic lithium.*

- Power Source (A/C power generated by the aeroplane);

- Data Connectivity
  Connectivity of the EFB to other aircraft systems is not allowed except:

  a) If the EFB connected to a transmission service that receives and transmits data for AAC purposes on the ground only, but is isolated from the avionics / aircraft systems

  and / or

  b) A receive only data link from aircraft systems, the data link must have an approved security device to protect the aircraft systems from receiving any data from the EFB;

- Rapid Depressurisation Testing
  EFB host applications continued function during and after rapid depressurisation.

5.1.2 Class 2

In addition to the approval requirements of 5.1.1 the Class 2 device must also demonstrate that:

- The physical mounting must not:

  a) Be located where it could obstruct visual or physical access to aircraft controls and displays and;

  b) Interfere with flight crew ingress or egress, or external vision;

  c) Impair user access to any item of the EFB system, even if stowed;

  d) Obstruct a clear view of the EFB display while in use;

  e) Impede the flight crew during duties (normal, abnormal, or emergency) associated with operating any aircraft system;

  f) Freely articulate but lock in position easily;

  g) Un-crashworthy;

  h) Impede flight crew egress from the flight deck (standard or emergency routes) or obstruct visual or physical use of flight controls and displays.

5.1.3 Class 3

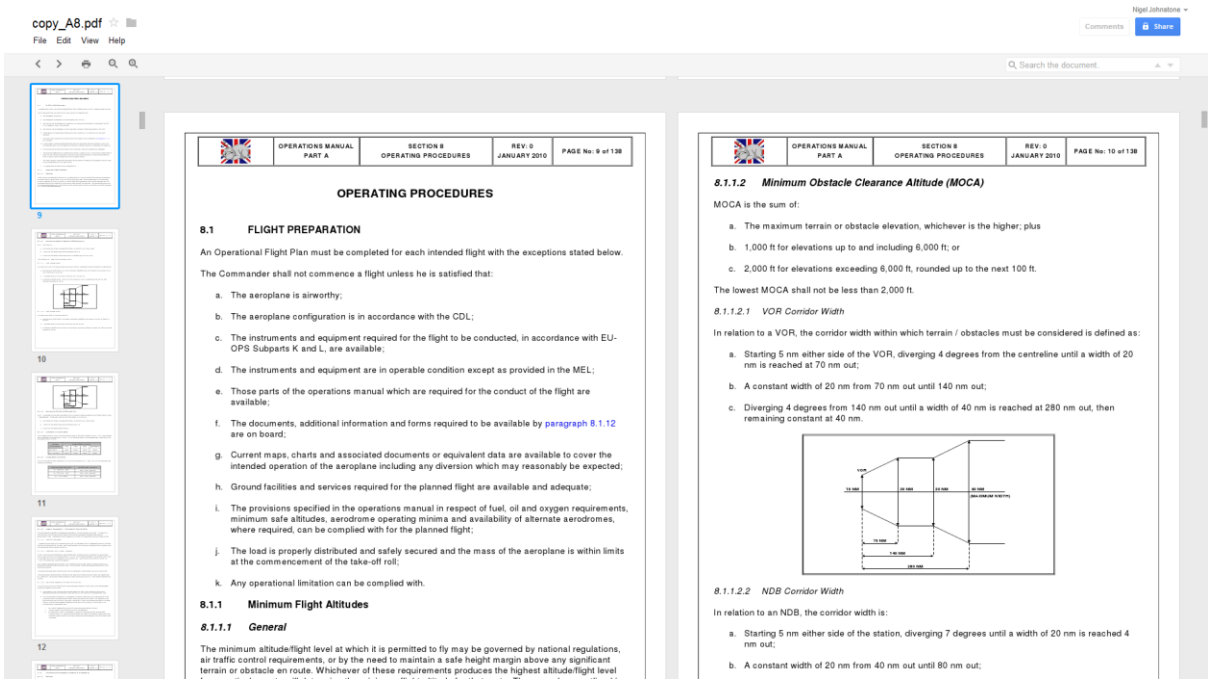
A Class 3 EFB requires an airworthiness approval as it is (usually) installed by the manufacturer.

6 PASSIVE USES

Passive software is classified as type A. EFBs, all classes, are able to render manuals, for example the AFM, FCOM as well as operations manuals OM Part A - D and the Cabin services manual, sometimes referred to as part E. In addition they can store administrational and operational forms which can be either printed or stored as an e-form, when displayed so that the user can interact with the e-form using the EFB. Examples could be the journey log or an ASR.

Summary of passive EFB tasking

- Electronic Data Library


copy_A8.pdf
File Edit View Help
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OPERATING PROCEDURES
8.1 FLIGHT PREPARATION
An Operational Flight Plan must be completed for each intended flight with the exceptions stated below.
The Commander shall not commence a flight unless he is satisfied that:
a. The aeroplane is airworthy;
b. The aeroplane configuration is in accordance with the CDL;
c. The instruments and equipment required for the flight to be conducted, in accordance with EU-OPS Subparts K and L, are available;
d. The instruments and equipment are in operable condition except as provided in the MEL;
e. Those parts of the operations manual which are required for the conduct of the flight are available;
f. The documents, additional information and forms required to be available by paragraph 8.1.12 are on board;
g. Current maps, charts and associated documents or equivalent data are available to cover the intended operation of the aeroplane including any diversion which may reasonably be expected;
h. Ground facilities and services required for the planned flight are available and adequate;
i. The provisions specified in the operations manual in respect of fuel, oil and oxygen requirements, minimum safe altitudes, aerodrome operating minima and availability of alternate aerodromes, where required, can be complied with for the planned flight;
j. The load is properly distributed and safely secured and the mass of the aeroplane is within limits at the commencement of the take-off roll;
k. Any operational limitation can be complied with.
8.1.1 Minimum Flight Altitudes
8.1.1.1 General
The minimum altitude/flight level at which it is permitted to fly may be governed by national regulations, air traffic control requirements, or by the need to maintain a safe height margin above any significant terrain or obstacle en route. Whichever of these requirements produces the highest altitude/flight level
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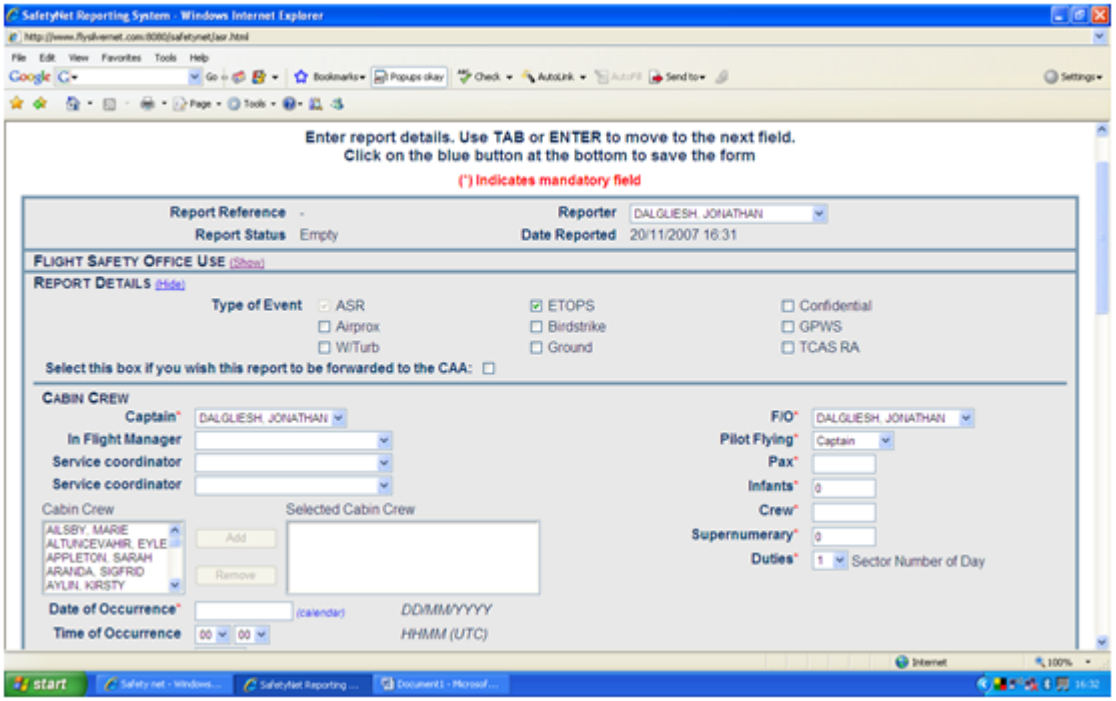
8.1.1.2 Minimum Obstacle Clearance Altitude (MOCA)
MOCA is the sum of:
a. The maximum terrain or obstacle elevation, whichever is the higher; plus
b. 1,000 ft for elevations up to and including 6,000 ft; or
c. 2,000 ft for elevations exceeding 6,000 ft, rounded up to the next 100 ft.
The lowest MOCA shall not be less than 2,000 ft.
8.1.1.2.1 VOR Corridor Width
In relation to a VOR, the corridor width within which terrain / obstacles must be considered is defined as:
a. Starting 5 nm either side of the VOR, diverging 4 degrees from the centreline until a width of 20 nm is reached at 70 nm out;
b. A constant width of 20 nm from 70 nm out until 140 nm out;
c. Diverging 4 degrees from 140 nm out until a width of 40 nm is reached at 280 nm out, then remaining constant at 40 nm.
8.1.1.2.2 NDB Corridor Width
In relation to an NDB, the corridor width is:
a. Starting 5 nm either side of the station, diverging 7 degrees until a width of 20 nm is reached 4 nm out;
b. A constant width of 20 nm from 40 nm out until 80 nm out;

- Reports
    a) Journey log or Voyage report;
    b) ASR and MOR;
    c) SEP Manual;
    d) MEL;
    e) AFM;
    f) Reference material;
    g) Dangerous Goods Instructions;
    h) Company forms;
    i) Airfield Briefings;
    j) Handling Agents Manual;
    k) Cabin Service Manual;
    l) Company email - *(note email handling software is deemed as non EFB software and must therefore reside in an area where it cannot interfere with EFB I/O operations. The EFB device hard disc must be partitioned so as to ensure continuous demarcation of non EFB software from EFB software).*

Example of an interactive Air Safety Report displayed within an internet browser



7 OPERATIONAL USES

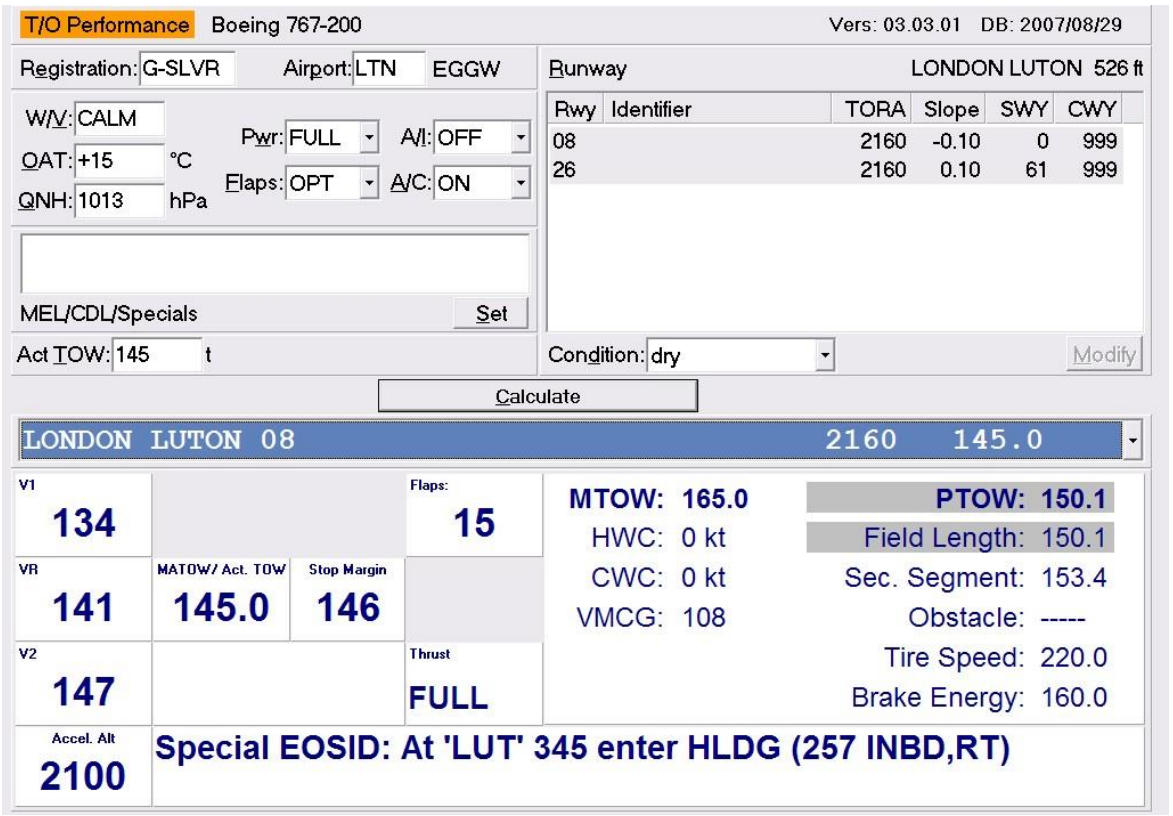
Operational software or software with which the user or on-board avionics systems interacts with, so as to execute data computation is classified as type B. The results of data computations that these types of software provide have direct implications for air safety. Calculated results are used for comparison with type certified design limitations and datum points upon which safety critical decisions are influenced.

Examples of Operational Type B software are:

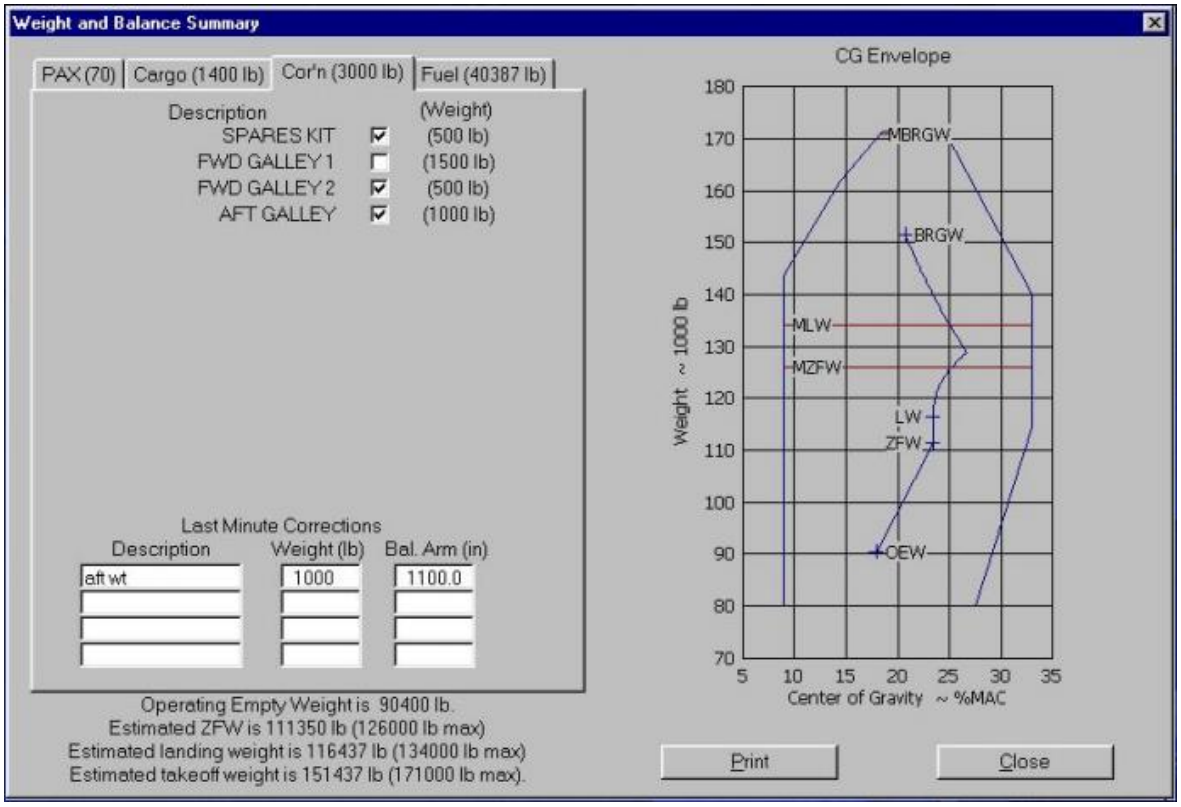
- Aircraft Performance Application e.g. Boeing Laptop Tool (BLT);
- Aircraft Mass & Balance Tool;
- En-route & Aerodrome Charts in electronic format e.g. JeppView, eAerad;
- Electronic Checklists.

This list is not exhaustive.

Example of a Take-Off and Landing Performance calculator. Note the provision, in this example, of emergency turn information. This software provider refers to an emergency turn as an 'EOSID' Engine Out Standard Instrument Departure! This is was not adaptable.



Example of a Weight and Balance (C of G) Calculator



8 IMPORTANCE OF POLICY

Both the FAA and EASA require the operator to develop policy and procedures for the use of the EFB and the administration of it and its supporting infrastructure. This is applicable to all commercial air transport operators but not to privately operated aeroplanes.

As you can see from paragraph 7 the information that the EFB is capable of giving and producing is exigent therefore policy that has been developed in conjunction with an EFB operational risk assessment is essential.

Regulatory documents from the FAA (AC 120-76A) and EASA (AMC 20-25) require that operators develop procedures for the use of an EFB so as to ensure that they do not provide inaccurate or misleading information to aircrew.

9 THREATS TO AIR SAFETY

Having briefly outlined the regulatory requirements for commercial air transport operators one could be forgiven for believing that strict control will prevent accidents and incidents. Regrettably this is not the case

9.1 Automation Reliance and Bias

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9.1.1 Why are people's decisions sometimes worse with computer support?

In many applications of computerised decision support, a recognised source of undesired outcomes is operators' apparent over-reliance on automation. For instance, an operator may fail to react to a potentially dangerous situation because a computer fails to generate an alarm. However, the very use of terms like "over-reliance" betrays possible misunderstandings of these phenomena and their causes, which may lead to ineffective corrective action. For instance, training or procedural changes are favoured responses, but they do not address all causes of apparently "over-reliant" behaviour. We review relevant literature in the area of "automation bias" and describe the diverse mechanisms that may be involved in human errors when using computer support. We discuss these mechanisms, with reference to errors of omission when using "alerting systems", with the help of examples of novel counterintuitive findings we obtained from a case study in a health care application, as well as other examples from the literature.

It has long been known that introducing automation might have unexpected side effects on human performance. For instance, consider a computer tool designed to highlight targets of interest on a radar screen. If the computer does not highlight one such target, even an experienced radar operator could be led to miss that target, even if he would not have missed it without the computer aid. Such phenomena are often attributed to complacency, which makes operators abdicate their responsibility to the automated support. Given this interpretation, a tool designer may assume this to be the main risk, and so proper training and indoctrination is the natural defence; this attitude is widespread in practice. We argue that this view is too simplistic, and present a much richer picture of unintended, subtle effects that automation may have and which a designer needs to be prepared to guard against.

Automation is increasingly taking on the role of supporting knowledge-intensive human tasks rather than directly replacing some of the human's functions. This actually makes the problem of computer-related human errors subtler. The responsibility for correct action rests

with the user. One might think that user mistakes can be reduced by simple training or, sometimes, by a user interface that prevents those mistakes. But in practice computers and their users form human-computer systems, or “socio-technical systems”, which need to be assessed as whole systems from the viewpoints of reliability and safety. Examples of these supportive systems are alerting systems: from spell-checkers to alarm-filtering systems for industrial control rooms through collision warning systems in transportation or computerised monitoring in health care. In these monitoring applications, automation typically assists the operator in judgement-oriented tasks, like dealing with anomalies and taking high-level decisions, by adding to situational data broadly “advisory” input: attention cues, pre-filtered alarms, suggested diagnoses, or even recommended manoeuvres. If operators “trust” the computer to help too much or too little, compared to their own judgement skills, reliability and safety of operation may suffer. Labels used in the literature are: “automation bias”, automation-induced “complacency”, “over-reliance” on automation, “automation dependence” or computer induced “confirmation bias”.

9.1.2 Automation Bias, Complacency and Trust

The phrase “automation bias” was introduced when studying the behaviour of pilots in a simulated flight. In this study, they encountered both omission and commission errors. These findings were then replicated with non-pilot samples (student participants) in laboratory settings simulating aviation monitoring tasks. They found that, when the automated tool was reliable, the participants in the automated condition made more correct responses. However, participants with automation that was imperfect (i.e. occasionally giving unreliable support) were more likely to make errors than those who performed the same task without automated advice. In the automated condition they were informed that the automated tool was not completely reliable but all other instruments were 100% reliable. Still, many chose to follow the advice of the automated tool even when it was wrong and was contradicted by the other sources of information. The participants had been biased by automation and interpreted their errors (especially their errors of omission) as a result of complacency or reduction in vigilance.

People’s ineffective use of computerised tools is often described in terms of “complacency”, which is said to cause over-reliance or “uncritical reliance” on automation. However, there is no general agreement about what exactly “complacency” is and what are the best ways to measure it. What seems to be common to most characterisations is a sense of contentment, unawareness of dangers or deficiencies and failure to look for evidence or to examine the raw data in a careful enough manner.

Another concept that is frequently invoked when talking about automation bias or (over) reliance on automation is “trust”. The common assumption is that the more a human operator trusts an automated aid the more likely he is to rely on or comply with the advice provided by the aid. If a human trusts an aid that is adequately reliable or fails to trust an aid that is indeed too unreliable, appropriate use of automation should occur as a result. However if a human trusts (and therefore follows the advice of) an unreliable tool, then automation bias may occur (or misuse of automation as defined above). Similarly if a person does not trust a highly reliable tool, the person may end up disusing (as defined above) or under-using the tool, and hence the full potential benefits of automation will not be fulfilled.

9.1.3 Conclusions

Errors that are often ascribed to “complacency” or “over-reliance” on computers can actually be caused by other mechanisms, in fact even when the operators do not trust the automated tool.

So, when designing a tool and the human-computer system to include it, it is certainly important to be aware of the risk of complacency (e.g. by prescribing appropriate training or procedures), but this may not be enough. In particular, we have shown that some of these error mechanisms may be an inherent part of the human cognitive apparatus for reacting to cues and alarms, so they cannot be effectively shut off. A proper design of the human-machine system would look for the best trade-off between the positive and negative effects, rather than assuming that negative effects can be completely eliminated; and evaluators and adopters, when assessing a design, need to be aware of these various facets of the effects of a tool.

Note: Fatigue and stress, as encountered by aircrew, has not been considered in this report.

9.2 Apperceptive Mass and the Assumption of Computer Infallibility

9.2.1 Apperceptive mass

Is the process whereby perceived qualities of an object are related to past experience. This is where an existing knowledge base in a similar or related area influences the way in which the new perceptual material is articulated or interpreted. Couple this with a computer users' implicit trust in the computer as an infallible authority or 'the computer never lies' and we have the beginning of a trail that leads to an accident or incident or more graphically put, the alignment of the holes in a Swiss cheese.

As computers have become even more and more common place in our daily lives, it has been extremely easy to be complacent and put absolute trust in them. However, this blind faith has led to many problems. Time after time, people are lured into a sense of security around computers that is dramatically shattered by some disaster. Although computers have provided many benefits to society, they have also provided their fair share of catastrophes. There have been many cases in which over-reliance upon computers have caused significant problems, but isolated instances do not necessarily indicate a trend. The human weakness regarding blind faith in the infallibility of computers leads to the absolute trust of a computer even above their own judgment? Some graphic examples of this are an incident involving a Corsair Fly B747-400 at Paris Orly.

In 2007, following the investigation of two serious incidents involving tail strikes that had occurred at Paris, Charles de Gaulle Airport (LFPG), a study entitled "USE OF ERRONEOUS PARAMETERS AT TAKE-OFF" was conducted by the Applied Anthropology Laboratory (LAA) at the request of Le Bureau d'Enquêtes et d'Analyses (BEA) and the French Civil Aviation Authority (DGAC).

The Incident

The Boeing 747-400 aircraft was scheduled to operate a long haul passenger service from Paris-Orly airport to the Antilles, with 15 crew and 563 passengers on-board. On arrival at the aircraft the pilots found that one of the two EFB laptops having the 'Boeing Laptop' (BLT) take-off performance data calculation application had a fully discharged battery and could not be used. Furthermore, a technical fault with a fuel scavenge pump meant that the crew had to consider 1.6 tonnes of fuel operationally unusable. During the pre-flight preparation the first officer observed indications of a hydraulic system fault and the engineer confirmed that it was being rectified.

The first officer used the serviceable second laptop's BLT application for the initial take-off data calculation. The Captain read out the ZFW and TOW from the loadsheet and the first officer entered the ZFW in the FMS and the TOW in the BLT application. The Captain had added 1.6 tonnes to the ZFW to account for the unusable fuel. The first officer entered the

other required parameters in the BLT to calculate the take-off speeds, assumed temperature for reduced thrust and flap setting, and then passed the laptop to the captain for confirmation. At the time the Captain was also discussing the hydraulic fault with the engineer. Later, the first officer found that he had inadvertently turned the laptop off, and the previously entered parameters had been erased. It was necessary once again to ask the captain for the TOW before he could perform a new calculation. When this was complete the captain entered the speeds and assumed temperature from the BLT into the FMS, replacing those calculated by the FMS itself. He queried the assumed temperature as it seemed high but the first officer explained that it was due to the low outside air temperature and high pressure.

The aircraft departed from the parking stand, taxied out and initiated a 'rolling' take-off. At V1 (take-off decision speed) the pilots began to recognise that the take-off performance was not normal and the Captain, as PNF, decided to delay the call for rotation. When the first officer did commence rotation he found that the aircraft was heavy in response, and as pitch attitude began to increase the 'stick-shaker' stall warning activated. The first officer reduced the pitch input and applied full take-off thrust, and the aircraft became airborne.

A runway inspection found metallic debris on the end of the runway and suspecting damage the aircraft returned to land after jettisoning fuel.

The Investigation
On the second occasion that the first officer requested the TOW, the investigation concluded that the Captain read out the ZFW instead but neither pilot recognised the discrepancy. As a result the first officer entered a weight some 100 tonnes below the TOW in the relevant field of the BLT. The BLT calculated the take-off data based on this erroneous weight and generated speeds (V1, VR and V2) approximately 30 knots lower than required, and an assumed temperature 9°C too high.

The FMS also automatically calculated V speeds and assumed temperature, based upon the ZFW and fuel on-board, which were in fact much closer to the correct values. However, because the FMS did not have access to all of the variable parameters used in performance calculations (pressure for example), the existing procedure required the crew to overwrite the FMS values with those from the BLT, which the captain did after the second erroneous calculation. The first officer subsequently checked that the FMS and BLT speeds and assumed temperature matched, which they did.

The recorded flight data (below) showed that full take-off thrust was applied several seconds after rotation commenced and as the aircraft lifted off. This was simultaneous with activation of the stick shaker. Evidence of tail strike was found on the aircraft aft fuselage after landing. The recommendations of the report indicate that distraction may have been a factor during the critical phases of take-off performance calculation.

Both apperception and automation bias have influenced the crew into ignoring their better judgement and accepting erroneous calculated data from the EFB (Boeing Laptop Tool). Validation of the take-off data parameters can be shown to be ineffective because they consist of verifying the input of the value but not the accuracy of the value.

9.3 Aircrew Distraction

In October 2009 an A320 aircrew became distracted from their flying duties after becoming engrossed with the use of their laptops. The following is an extract from the NTSB report into the incident.

On October 21, 2009, Northwest Airlines (NWA) flight 188, an Airbus A320, N374NW, did not communicate with air traffic control (ATC) for approximately 1 hour 17 minutes. While the flight was NORDO, it flew past its intended destination at cruise altitude of 37,000 feet but landed without further incident after radio communication was re-established.

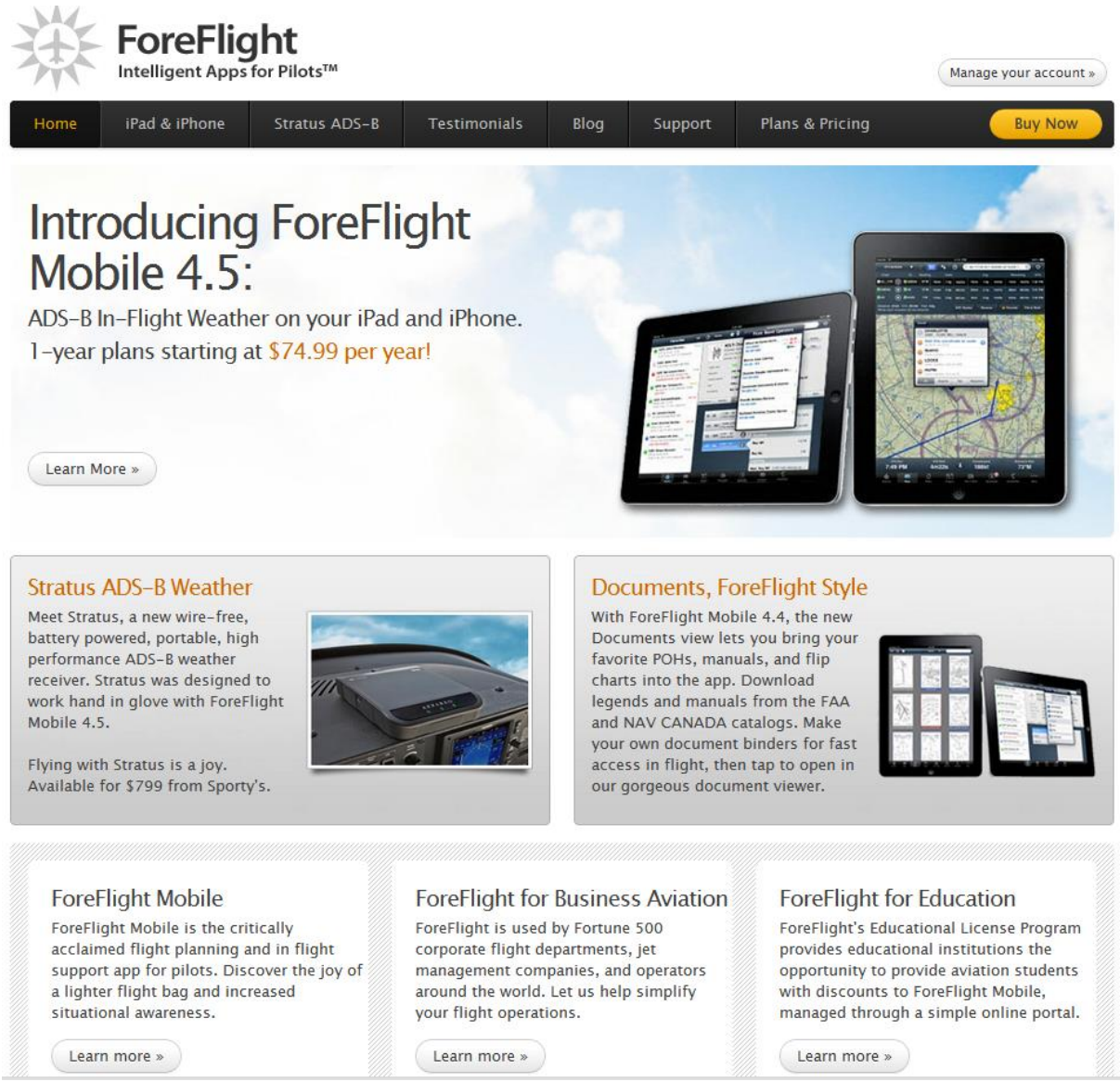
According to pilot interviews, after completing their meals, the pilots began a conversation regarding the current Preferential Bidding System for crew scheduling. The Delta Air Lines PBS system had been recently implemented as part of the integration of NWA and Delta Air Lines. Both pilots characterised the system as confusing. They had received and read the manual and been provided training in the new computer-based system. The pilots' reported that their discussions mainly concerned the captain's bid results for November. He had not received the bid results he had anticipated, and the results he received required him to commute to MSP more often than in the past. When interviewed, the captain indicated that he pulled out his laptop computer to show the first officer his bid results. The captain stated that, with his laptop out, his view of the PFD was not blocked.

The first officer stated that, after 4 to 5 minutes of conversation, he pulled out his laptop computer and placed it on top of the extendable tray table in front of him. The first officers said that both laptops were out and open at the same time. Both pilots stated that the first officer was tutoring the captain in the bidding system and process. They also stated that they did not hear any audible alerts in the cockpit and did not see any ACARS message indications on the ECAM during the time they had their laptops out. The captain stated that he believed the conversation regarding the bidding procedures lasted about 15 minutes. The pilots stated that their first indication of anything unusual with the flight was when they received a call from a flight attendant inquiring about their arrival. The captain said that he then looked down at his multifunction control and display unit (MCDU) and saw that there was no flight plan information depicted. Then, the captain looked at his navigation display and saw Duluth to his left and Eau Claire to his right. The first officer said that he then immediately contacted ATC, but neither pilot could remember what frequency was used. ATC gave them a frequency to use to contact Minneapolis ARTCC. The first officer then noticed the ACARS message indication on the ECAM and attempted to retrieve those messages.

9.4 iPad on the Flight Deck

Since the iPad became available in 2010 a revolution has taken place in mobile computing which has taken the market by storm. The iPad has become a milestone as far as computing is concerned and it did not take long for this device to find its way onto the flight deck. The iPad runs software which Apple refers to as an app' (which is a truncation of the word application). Apps are sold exclusively through 'iTunes' which is Apple's exclusive online store.

There are many apps that provide facilities for the operations and navigation of aeroplanes. The author is not aware of NAA approval for the operational use of these apps. The following is an example of the type of aviation software that is currently available for sale on iTunes:


ForeFlight
Intelligent Apps for Pilots™
Manage your account »
Home
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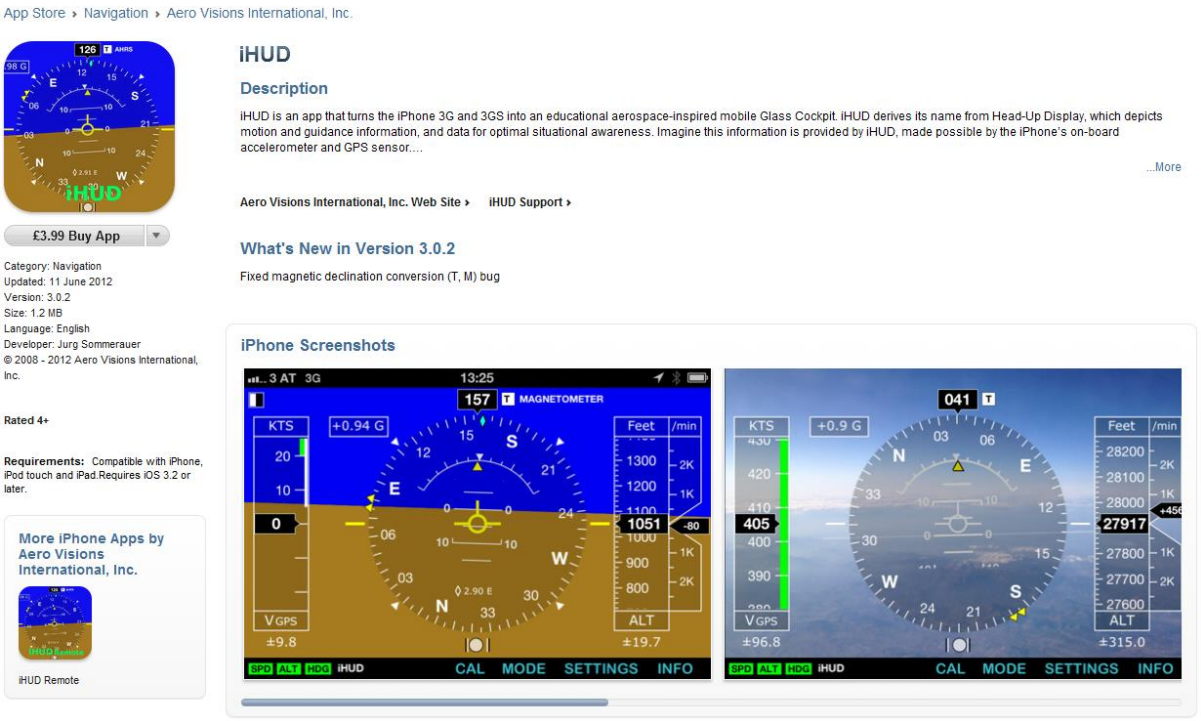
Other examples include GPS, Head Up displays, Weight and Balance, aircraft performance, navigation charts (IAC and enroute) etc. There are two forums dedicated to the iPad for aviation on the linkedin web site.

The adaptation of the iPad for use as an EFB is predominately led by software developers, not pilots or flight operations professionals. The usability and affordability of the iPad has generated considerable interest, from private and commercial operators, and this interest threatens to overwhelm regulators.

This is from the ‘iTunes’ Store:


App Store › Navigation › Aero Visions International, Inc.
iHUD
Description
iHUD is an app that turns the iPhone 3G and 3GS into an educational aerospace-inspired mobile Glass Cockpit. iHUD derives its name from Head-Up Display, which depicts motion and guidance information, and data for optimal situational awareness. Imagine this information is provided by iHUD, made possible by the iPhone's on-board accelerometer and GPS sensor....
...More
Aero Visions International, Inc. Web Site ›
iHUD Support ›
What's New in Version 3.0.2
Fixed magnetic declination conversion (T, M) bug
£3.99 Buy App
Category: Navigation
Updated: 11 June 2012
Version: 3.0.2
Size: 1.2 MB
Language: English
Developer: Jurg Sommerauer
© 2008 - 2012 Aero Visions International, Inc.
Rated 4+
Requirements: Compatible with iPhone, iPod touch and iPad.Requires iOS 3.2 or later.
More iPhone Apps by Aero Visions International, Inc.
iHUD Remote
iPhone Screenshots
MAGNETOMETER
CAL MODE SETTINGS INFO

9.4.1 FAA ASRS Database of Incidents Involving the iPad

These are extracts from FAA Air Safety data bases of reported incidents where the use of an iPad has been cited as being a causal or contributing factor.

Date : 201104
Flight Conditions : VMC
Light : Daylight
Qualification.Flight Crew : Flight Instructor
Qualification.Flight Crew : Air Transport Pilot (ATP)
Small Aircraft, Low Wing, 2 Eng., Retractable Gear

A pilot reported that he became distracted while navigating with an iPad and failed to realise he had entered Class D airspace until he visually sighted the airport. “I had a paper sectional chart and new iPad with scanned sectional chart (both current). Was using ATC for SFRA services and was terminated north of BWI. Began to use iPad for navigation, but had it "zoomed in" too far and lost track of the big picture.”

Date : 201104
Flight Conditions : VMC
Qualification.Flight Crew : Private
Qualification.Flight Crew : Instrument
Skyhawk 172/Cutlass 172

A C-172 pilot, engrossed in an improperly configured EFB and distracted from essential pre take-off tasks such as properly aligning his gyro compass, took off from TUS, turned 180 degrees the wrong way when given a vector and failed to expedite his climb above 4,000 MSL as requested by ATC.
"I was using for the first time an iPad for the airport diagram, but it was not working for me because I had not downloaded the App properly the night before, so it took me a while to figure out where to go, and it frustrated me not a little."

Date : 201103
Flight Conditions : VMC
Light : Daylight
Qualification.Flight Crew : Private
Qualification.Flight Crew : Instrument
SR22

An instrument rated SR22 private pilot failed to note the heading after departure directed by the Van Nuys SID from BUR. A track deviation and a separation issue with a departure off another runway ensued. The reporter's recent change to an iPad based EFB utilizing NACO vice commercially provided aero charts was a contributing factor.
"I had not been using the iPad very long for in-flight use so was relatively unfamiliar with the NACO plates as I had previously been using commercially prepared plates. I did not sufficiently brief the narrative on the second page and thus got confused about my assigned heading for the initial climb."

Date : 201102
Flight Conditions : IMC
Light : Daylight
Qualification.Flight Crew : Air Transport Pilot (ATP)
Qualification.Flight Crew : Flight Instructor
SR22

A SR22 had a track deviation because the on board Garmin 430 was improperly programed from iPad data because the iPad settings did not include intermediate VOR's on the airway.
"The problem arose because the airway was read from an iPad and the settings menu was not set to include fixes between VOR's. In an effort to meet a void time this was not double checked and the intersection that defined the airway was not included."

Date : 201101
Flight Conditions : VMC
Light : Daylight
Qualification.Flight Crew : Instrument
Qualification.Flight Crew : Commercial
Cardinal 177/177RG

C177 pilot reports selecting the wrong instrument departure procedure on his iPad resulting in a track deviation departing VGT.
"I was using Wing X PRO on an iPad for chart reference and inadvertently loaded the BOULDER CITY ONE departure. At 4000 msl during the climb and before reaching the LAS R-300, 9-DME, Approach asked me if I was sure I was on the NORTHTOWN TWO departure and said "yes getting ready to turn left now" (this was correct for the BOULDER CITY ONE but not for the NORTHTOWN TWO)."

Date : 201012
Flight Conditions : VMC

Light : Daylight
Qualification.Flight Crew : Private
Small Aircraft, High Wing, 1 Eng, Fixed Gear

A single engine pilot navigating VFR using landmarks and an iPad with GPS navigation software flew into a corner of DEN Class B airspace when he got distracted and did not have the software scrolled to the Class B in his area.
"Another technique would have been to request VFR services from DEN TRACON for this flight and clearance into the Class Bravo airspace, which I normally do for almost all of my cross-country flights, but this day I did not due to not wanting to be distracted by the radio chatter while trying out the new GPS software on the iPad device."

Date : 201011
Flight Conditions : VMC
Light : Night
Qualification.Flight Crew : Commercial
Qualification.Flight Crew : Instrument
Citation II S2/Bravo (C550)

A CE-550 pilot distracted in a climb while attempting to reset the brightness display on his iPad flew through his cleared altitude.
"I had just purchased a new iPad with a moving map chart and was using it for the first time that night. During climbout, I was distracted by the brightness of the iPad display; it was so bright that it was interfering with my cockpit scan. But to adjust it requires closing the program and going to the settings page. It only took a minute or so to do it, but we were climbing at 3,000 fpm or better. When I looked up I saw that the autopilot had not intercepted the selected altitude and the aircraft was passing through 15,500 FT."

Date : 201010
Flight Conditions : VMC
Light : Daylight
Qualification.Flight Crew : Air Transport Pilot (ATP)
Qualification.Flight Crew : Flight Instructor
Small Aircraft, High Wing, 1 Eng, Fixed Gear

A VFR pilot reported using an iPad to navigate in the LAX area's complex airspace and possibly entered Class C and Class D airspace.
"I might have relied on the iPad a little too much, thus possibly causing me to clip Class C and Class D airspace without establishing the appropriate communications. Why did I allow this to happen? I simply placed too much trust in the iPad's moving map information and didn't use pilotage often enough to verify its accuracy.[…] While this may be a serious issue with this particular moving map display, it's ultimately more an issue with me, the pilot. Normally I don't rely "solely" on moving map information for avoiding some types of airspace. Clearly this was an amateur's mistake on my part."
Reporter stated he believes the degradation in position location was associated with the lack of an external antenna. He believes refreshing property was limited to the last known position, which accounted for the lag in location information, thus the airspace incursions.

Date : 201009
Flight Conditions : VMC
Light : Daylight
Qualification.Flight Crew : Private
Make Model Name : Skyhawk 172/Cutlass 172

An iPad personal electronic device, not inflight certified, was used for VFR navigation and about two hours into the flight at 10,500 FT overheated and shutdown.
"During cruise approximately two hours into the flight, the iPad displayed a notice indicating that it had overheated, and shut down within about five seconds. I had paper charts available and used them to continue the flight, though it took a couple of minutes to find the correct position on the chart and fold it appropriately. Had this happened during a complicated instrument approach, especially without paper charts both available, safety could have been impacted. Although the temperature in the cockpit was quite comfortable, it was a sunny day, research indicates that the large screen of the iPad acts thermally like a black surface, so considerable heat can be absorbed from the direct sunlight.[…] Certified electronic flight bags are presumably designed for a wider range of cockpit environments than much cheaper consumer products like the iPad; pilots are encouraged not to rely on such consumer devices, but I think this particular failure should be more widely communicated. Despite being a professional electrical engineer, I certainly did not anticipate it."

Date : 201010
Flight Conditions : VMC
Light : Daylight
Qualification.Flight Crew : Private
Qualification.Flight Crew : Instrument
Small Aircraft, Low Wing, 1 Eng, Retractable Gear

A pilot reported entering the PCT SFRA as he was attempting to avoid a warning area but did not have either his GPS or area charts to track his location and stay clear of the SFRA.
"I need to be careful when using the new iPad format in the zoom and should have the paper maps for back up to see more of the area and not just a limited area that is shown on the IPad."

Date : 201008
Flight Conditions : VMC
Light : Daylight
Qualification.Flight Crew : Private

A distracted private pilot flying, utilized an Apple iPad for navigation assistance, clipped IWA Class D airspace while focusing on how to use the program installed.

"I was using a new GPS program called "Foreflight" installed on an Apple iPad. Upon receiving my instructions from FFZ I switched the iPad from the GPS navigation screen to a writing scratch pad to write down my landing instructions. With my head down concentrating on learning how to use the new program I lost my heading and inadvertently clipped the IWA airspace."

9.5 Software Errors and Program Design

Application software is prone to errors that can have sinister repercussions. The BLT at the time of the fatal B747-200F crash in Halifax had a reversion feature which the crew were not aware of. Therefore the data used to calculate take-off performance was incorrect and this lead to the fatal crash (*see Annex E Incident and Accident Reports*). This is an extract from the accident report:

"2.8 Summary
The take-off data card was most likely completed using performance data from the BLT. The FDR data for the Halifax take-off was nearly identical to that of the Bradley take-off, indicating that the Bradley take-off weight was used to generate the performance data in Halifax. The Bradley weight in the weight and balance page was likely unknowingly

*transferred to the performance page **due to a reversion feature of the software**. The user subsequently selected calculate, which resulted in the generation of take-off performance data containing incorrect V speeds and thrust setting for Halifax. The flight crew used the incorrect V speeds and thrust setting during the take-off attempt; however, the settings were too low, especially the thrust setting, to enable the aircraft to take off safely."*

This feature of the BLT software design is now the subject of litigation with the software developers. Since this accident the Boeing weight and balance and performance calculator has been subject to changes, for example the name has been changed to the 'OPT' On-board Performance Tool' This original program feature has not produced a computational error in that the results of the computation on the input data were correct. When this feature was included in the original software program design the possible catastrophic consequences had not been foreseen or considered.

When evaluating software, as a part of a submission for permission of use, software errors have been discovered with weight and balance and take-off and landing calculators. With one EFB software provider the performance calculator would not provide a warning when the calculated performance limiting take-off weight was less than the planned or actual take-off weight. It provided V speeds for the MTOW achievable which provided an opportunity for an attempted over weight take-off. This software was in operational use with another operator at the time of the author's evaluation, and has subsequently been revised.

With another operator who was planning to use the OPT a problem was encountered that lead to an OPT user notification:

Following is a quote from Boeing OPT User Notification:

"It is possible under some circumstances for OPT (version 3.4 only) to clear passenger count data entered by the crew, resulting in a lower operational weight than the actual airplane loaded configuration.

One OPT Stand-alone operator reported a condition where some of the entered values for number of passengers loaded in specific passenger zones was being erased when the crew re-enters the Weight and Balance screen to update information for some of the parameters. In this case, the operator noticed that the entries in the right-hand column on the passenger zone tab were getting deleted, resulting in a different weight configuration than originally entered.

Boeing has traced this behaviour to be applicable to operators who use the Weight and Balance feature, and have more than 10 passenger zones defined, while using a single passenger type. This behaviour does not occur when using multiple passenger types, or when using 10 or fewer passenger zones. When configured with a single passenger type and more than 10 passenger zones, OPT assumes a two-column format for the input screen. When the user enters passenger count data into the entry boxes in the second column, selects the COMPLETE button to return to the OPT main screen, and subsequently selects the WEIGHT AND BALANCE button to return to the Weight and Balance screen, the passenger count entry boxes in the second column are cleared by the program. This results in a lower operational weight, and different centre of gravity (CG) value than for the originally entered configuration. The cause of this behaviour has been identified, and will be corrected in OPT v3.5, scheduled for release in 3rd quarter 2011. In the meantime, Boeing has identified the following options as 'work-around' solutions to mitigate this behaviour until the new version of OPT is released."

10 ACCIDENTS AND INCIDENTS TO DATE INVOLVING EFB'

Since the introduction of the EFB onto the flight deck there have been numerous incidents, many serious or near fatal and, as previously described, one fatal accident of a B747F in Halifax Nova Scotia which was attributed to pilot failure to update an EFB.

Of the 67 ASR (FAA) accounts, between 1995 and August 2009, identified as relevant, 32 reports pertain to the use of charting applications and 30 pertain to computation of flight performance.

ASR's related to use of the EFB chart software were most often filed by Part 91 and Part 135 operators. Many of these reports concerned events that unfolded during climb out, an intense and short phase of flight. Charting related ASRS reports mentioned outcomes such as deviations in heading, altitude, and speed.

All of the ASR that were related to flight performance calculations were filed by Part 121 operators. Issues related to flight performance computations were most often identified on the ground (pre-flight, taxi, or during the take-off roll), but they were occasionally identified later in the flight. Typical outcomes included company policy deviations (e.g., take-off from an unauthorised runway) and incorrect take off speeds or incorrect weight and balance data.

Ten ASRS reports of runway incursions were identified with the EFB (see Annex D) as a contributing factor. These events were not specific to any one software application; they appear to occur when one member of the flight crew is preoccupied with the EFB.

A list of EFB issues was created iteratively based on the data in the set. Three key EFB issues were identified. First, configuring the EFB display for chart readability can induce workload and may cause the pilot to miss important information. However, larger EFBs are not necessarily a solution, as some reports also mentioned difficulty using the larger EFBs in small flight decks. Second, anomalies associated with flight performance calculations included company policy deviations, incorrect computations, and runway incursions. Computing flight performance can absorb a pilot's attention fully, distracting him or her from the usual multi-tasking flight duties. Flight deck procedures may need to be emphasised to ensure that pilots continue to monitor other tasks while they do the flight performance calculations. Third, some pilots who were new to the EFB mentioned that difficulty using the EFB contributed to the event. Further initial training may be valuable, particularly for Part 91 and Part 135 operators who filed the majority of these reports mentioning this issue.

Both NTSB accident reports discussed in this report identified use of an EFB for calculating landing distance as a contributing factor in the accident. One issue was that assumptions underlying the performance calculations on an EFB must be presented to the crew as clearly as on paper-based performance tables. A second issue was assessment of the adequacy of training and procedures for using EFB performance calculations functions. These reports emphasise the need for proper user-interface design of the flight performance calculation software for EFBs, and proper assessment of crew training and procedures for the use of the EFB.

Note that due to the difficulty in obtaining accident and incident statistics from European agencies, most of the statistics quoted in this report come from FAA and NASA sources.

10.1 Accident and Incident Reports

These are appended into annex D and E

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Take-off calculation error led 737 to overrun short runway

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By: DAVID KAMINSKI-MORROW LONDON 06:00 5 Sep 2011

Source: FLIGHT

French investigators have deter-mined that an Egyptian Boeing 737-800 crew failed to account for a shortened runway during take-off at Paris, colliding with obstacles on rotation and flying low over a blast fence.

Despite damage to the twinjet, the AMC Airlines crew did not report the collision to air traffic control and continued the flight to Luxor. The incident was only discovered when a taxiing aircraft reported debris on the runway three hours later, and several days passed before the 737 involved was formally identified.

French investigation agency Bureau d'Enquêtes et d'Analyses (BEA) said the 737 was cleared to take off on Runway 27L from taxiway Y11. Construction work meant the last 1,240m (4,070ft) of 27L was closed, and the intersection take-off cut a further 280m from the available distance.

Communication difficulties with Egyptian authorities meant the flight-data recorder had been overwritten before analysis of the 16 August 2008 incident.

Paris air traffic control told the crew that 2,360m of runway remained. But radar data indicated the 737 became airborne after 2,520m - some 160m beyond the provisional runway end - and investigators found damaged marker blocks and crushed lights where the work zone began.

AMC staff found the 737 had sustained minor engine cowl, stabiliser and landing-gear damage.

The carrier's pilots used Boeing OPT software, on laptops, to determine characteristic take-off speeds. BEA found that "failure to take into account the runway restriction" while using OPT explained the event.

It has recommended the European Aviation Safety Agency to study standards for certification of such onboard calculation systems to ensure ergonomics and procedures are "compatible with the requirements of safety".

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10.2 CAA MOR Database

The following data concerning incidents and accidents during take-off due to the use of incorrect take-off performance parameters has been sampled from the CAA MOR database.

Data was sampled from the databases between 01 JAN 1990 to 01JUN2012 using query keywords FMC PERF COMPUTER INCORRECT INSUFFICIENT DATA ENTRY TAKE-OFF TAXI PHASE UK AOC >5700KGS

Incident	Date Range	Nbr
Incorrect V Speeds set in FMC	1999-2012	48
weight data other than ATOW or ATOM used for performance calculation	1999-2012	17
EFB generated Incorrect V speeds after data entry error	2008-2011	3
incorrect V speeds produced by ground staff using the FOVE (EFB type B software)	2008	1
3 EFB could not agree one EFB performance calculator being used by ground staff	2009	1
Incorrect v speeds as a result of departure runway change during taxi and one of these where the wrong runway was used	2006-2010	8
serious incidents that involved the AAIB	2008-2009	3
Wrong load sheets used to calculated take-off performance	2008	1

10.2.1 CAA MOR Data Base Incidents Specifically Involving EFBs

All of the MOR's used to produce the data table in 10.2 can be found in Annex G

11 CONCLUSIONS

Though the business case for EFB systems is compelling many operators are deterred by the initial set-up costs; which are high. Until recent times the EFB has become the badge of large operators with deeper pockets, but with the introduction of cheap tablet computers which are simpler to use, this is all set to change.

The proliferation of cheap EFB devices on the flight deck of airliners brings with it an escalation of risk that threatens to overwhelm the regulator and therefore reduce oversight. Promotion of the use of tablet (touch screen device type) by developers, not pilots, has reached near craze levels and the gimmick potential of this machine is encouraging software developers to rush to explore ever opening opportunities. Essentially touch screen tablets computers are built exclusively for the leisure market, though they do offer some business applications. The efficacy of their use on the flight deck as a tool that provides safety critical data needs to be empirically established by a responsible body. Some airline operators have bought thousands of these machines and this could bring pressure on regulators to waive their better judgements should evaluation of them prove unsatisfactory.

The regulation of EFB's, in Europe needs to be re-evaluated and tightened. For example in AC120-76A there is a requirement for flight dispatchers to be trained in the use of the operators' EFB but this is not a requirement in Europe. The AAIB report into the A330 incident at Montego Bay also fails to make any recommendations with regards to the training of ground operations personnel. This must be changed and AMC 20-25 should include the requirement for the training of any staff member that is required to use the EFB and associated software applications.

Computers have everyday benefits but our reliance on them abstracts us from processes that we should be more closely involved with. This is 'automation loafing' and when this is coupled with apperceived mass and automation bias, when handling safety critical data, the results can be potentially dangerous. Perhaps the aviation industry could learn from practices and experience from the medical profession, in this area.

Computers on the flight deck are a distraction and the use of personal laptops or mobile computing devices on the flight deck during flying operations should be prohibited.

11.1 Data Entry Errors (HMI)

FMC CDUs and MCDUs have non-conventional keypads. Their keyboards have an ABCDE arrangement whereas a standard EFB device has QWERTY keyboard, which is the computer industry standard. The non-standard arrangement of the FMC CDU makes it an unfamiliar device as far as data entry is concerned and this may lead to less data entry errors because of the non-familiarity of the keyboard so that each relevant data entry key has to be visually identified before it is depressed. Therefore every key depression event has to be a deliberate and considered action whereas as a QWERTY keyboard can be used blindfolded. This is conjecture and I have no evidence to support this.

The QWERTY keyboard was designed for the Sholes and Glidden typewriter in the early 1870's and is now the most common keyboard layout in the world featuring on most computer data input keyboards.

This is a standard computer keyboard layout. Most laptop and notepad computers are not large enough to have a separate numeric keypad so the numbers keys are located above the character keys.

Note: Though tablet computers have touch screen QWERTY keypads the numeric key pad is separate and accessed by pressing on the *key.*

11.2 Minimum Number of EFB Devices on the Flight Deck

If the EFB is intended to provide operational data then the minimum number of EFBs required should be two not one. This should be the absolute minimum for performance calculation cross checking.

When take-off performance calculations are completed using paper systems i.e. tabular performance pages; only one book is required and the data extrapolation is carried out independently by each crew member. So the SOP is likely to be LHS carries out the first performance calculation using data from the final load sheet and ATIS which the LHS has independently acquired. The results are recorded and the book is shut and passed to the RHS who now performs an independent reiteration of the actions of the LHS. The performance results obtained by the RHS are recorded and then the two sets of results are compared. This is a double blind test and a safe way of ensuring the correct results are achieved. It is not practical to replicate this process when using only one computer or EFB (Class 1 or 2) because of the data retention capability of the machine and (in some cases) data reversion properties of the program, has the potential to corrupt or interfere with the

next data inputs and the time required to shut down and reboot after the first independent calculation has been completed.

11.3 Take-Off Performance Monitoring Systems

After considering the B747-200F accident in Halifax Nova Scotia, the Transportation Safety Board of Canada made a safety recommendation to Transport Canada and the ICAO that:

"*The Board recommends that:*
The Department of Transport, in conjunction with the International Civil Aviation Organization, the Federal Aviation Administration, the European Aviation Safety Agency, and other regulatory organizations, establish a requirement for transport category aircraft to be equipped with a take-off performance monitoring system that would provide flight crews with an accurate and timely indication of inadequate take-off performance."

After the A330 incident in Montego Bay the UK AAIB made a safety recommendation 2009-080 and 2009-081

"Safety Recommendation 2009-080
It is recommended that the European Aviation Safety Agency develop a specification for an aircraft take-off performance monitoring system which provides a timely alert to flight crews when achieved take-off performance is inadequate for given aircraft configurations and airfield conditions.

Safety Recommendation 2009-081
It is recommended that the European Aviation Safety Agency establish a requirement for transport category aircraft to be equipped with a take-off performance monitoring system which provides a timely alert to flight crews when achieved take-off performance is inadequate for given aircraft configurations and airfield conditions."

Despite the thoroughness of cross checking, and calculated performance data validation procedures, take-off incidents where incorrect performance parameters were used, still occur. No matter how robust cross checking procedures are they will not prevent an incident if an incorrect weight data is used in the first place.

Progress in EASA with regarding TPMS has been slow and the ASG should seek to expedite this process.

11.4 Training

AMC 20-25 should be amended to include the requirement that all personnel involved in the use, administration and support of flying operations where an EFB is used must be trained in its use and operations. AMC 20-25 currently requires that aircrew and personnel involved in administration of the EFB (7.09) and flight crew (7.12) should be trained and details training plans. There should be no differential, in EFB training plans, between aircrew and other ground personnel.

11.5 Batteries

AMC 20-25 requires that fully charged back up batteries for Class 1 and 2 devices be available on the flight deck. This will make life difficult for current iPad device users as iPad batteries are not designed to be interchanged by the user.

EFB battery fires, though not common, have been reported in 3 separate incidents on-board UK registered airliners between 2009 and 2011. Currently LIB's fitted to B787 Dreamliner's have caused the entire global fleet to be ground after a serious fire on-board a Japanese B787 in Boston USA. Investigations into this fire are on-going at the time of writing.

LIB's that are used in EFB devices in the UK must comply with Universal Laboratory testing standards UL1642 Edition Number: 5 Edition Date: 03/13/2012.

According to UL documentation:

1.3 These requirements are intended to reduce the risk of fire or explosion when lithium batteries are used in a product. The final acceptability of these batteries is dependent on their use in a complete product that complies with the requirements applicable to such product.

1.4 These requirements are also intended to reduce the risk of injury to persons due to fire or explosion when user-replaceable lithium batteries are removed from a product and discarded.

1.5 These requirements cover technician-replaceable lithium batteries that contain 5.0 g (0.18 oz) or less of metallic lithium. A battery containing more than 5.0 g (0.18 oz) of lithium is judged on the basis of compliance with the requirements in this standard, insofar as they are applicable, and further examination and test to determine whether the battery is acceptable for its intended uses.

1.6 These requirements cover user-replaceable lithium batteries that contain 4.0 g (0.13 oz) or less of metallic lithium with not more than 1.0 g (0.04 oz) of metallic lithium in each electrochemical cell. A battery containing more than 4.0 g (0.13 oz) or a cell containing more than 1.0 g (0.04 oz) lithium may require further examination and test to determine whether the cells or batteries are acceptable for their intended uses.

1.7 These requirements do not cover the toxicity risk that may result from the ingestion of a lithium battery or its contents, nor the risk of injury to persons that may occur if a battery is cut open to provide access to the metallic lithium.

What the above does not cover is the testing of LIB's that are constantly charging as they are on the flight deck of an aeroplane when providing power for an EFB, and the stress that this places on the battery.

The ASG believes that aircrews will have great difficulty in extinguishing LIB fires or thermal runaways in an EFB used on the flight deck or in avionics bays, or even from PEDs in the cabin. Furthermore, testing of such scenarios would appear incomplete after the recent spate of issues in the B787. Fire suppression is further complicated when the battery is hidden inside the computer as it is in the iPad and the tablet PC (android).

Note: Thermal runaway is where an increase in temperature changes the conditions in a way that causes a further increase in temperature, this condition can trigger an exothermic reaction. Thermal runaway is typically associated with increased current flow and power dissipation.

Mobile computers come with circuitry that is designed to prevent thermal runaway;but are these safety systems tested by the regulator before they are sanctioned for operational use on commercial airliners? Certainly the recent B787 battery fires would suggest that they are not.

12.0 SUMMARY

EFBs are useful devices that can reduce pilot workload and augment air safety when used correctly. This report is not recommending that EFB's be banned from use; on the contrary, the Air Safety Group believes that every operator should use them.

The problem with the EFB comes with the over reliance and misplaced faith that pilots place on them. This misplaced faith, or complacency, is also a concern. Safety critical data generated by EFB computers should, in theory, be treated with a healthy level of circumspection by experienced pilots, yet this seems not to be the case. Why is that?

When reading the AAIB report into the serious incident involving an A330 (G-OJMC) take-off from Montego Bay, even a 26 kt error in the Vr speed (Vr 114 kts should have been 140kts) went unnoticed by 3 pilots one of whom was a training captain.

Safety when using EFBs could be improved with more robust regulation from EASA and the FAA requiring operators to improve their EFB operating policies, minimum equipping, training and the mandatory fitment of TPMS on every fixed wing commercial air transport aeroplane. The ASG believes that more research needs to be completed into automation bias and complacency and that this research should be used in the development of robust EFB handling policies.

R Nigel Johnstone
Air Safety Group

ANNEXES

Annex A FAA AC 91-78 Use of Class 1 & 2 EFBs

Click to view the document online

Annex B JAA TGL36

Click to view the document online

Annex C EASA AMC 20-25

Click to view the document online

Annex D EFB Ergonomics

These are exerts from a Serious Incident report from the Hong Kong Civil Aviation Department concerning an attempted take-off from a taxi way involving an A340 aircraft. The difficulties in stowing the Class 1 EFB are cited as a reason for this incident.

Operator	:	Finnair Oyj (Finnair)
Aircraft Type	:	Airbus A340-300
Nationality	:	Finland
Registration	:	OH-LQD
Flight Number	:	FIN070
Place of Incident	:	Hong Kong International Airport
		Latitude: 22 18 32N
		Longitude: 113 54 53E
		Elevation: 28 Feet (ft)
Date and Time	:	26 November 2010 at 1724 hours
		(All times in this report are in Co-ordinated Universal Time (UTC) unless otherwise stated.)

SYNOPSIS

The incident occurred at 1724 UTC on 26 November 2010 (0124 on 27 November 2010 Local Time (LT)) at Hong Kong International Airport (HKIA), when one of the two parallel runways, namely the south runway (RWY 07R/25L), was closed for regular maintenance in accordance with the runway maintenance programme as published in the Hong Kong Aeronautical Information Publication (AIP). The north runway (RWY 07L/25R) remained operational with RWY 07L in use for both arrivals and departures. The weather was fine with a prevailing visibility of 10 kilometres (km).

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FIN070 was a scheduled public transport flight from HKIA to Vantaa Airport, Helsinki, Finland. There were three crew members on the flight deck. In addition to the Captain and the First Officer, there was a Relief Pilot who was in the first observer's seat. In accordance with company procedures, the Captain was responsible for taxiing and the aircraft proceeded to RWY07L Holding Point via Taxiway (TWY) B, a taxiway parallel to the north runway, as cleared by Air Traffic Control (ATC).

When FIN070 was approaching the RWY 07L Holding Point towards the western end of TWY B, the Air Movements Controller (AMC) cleared the aircraft for take-off. The aircraft took the normal right turn at the end of TWY B onto TWY A1 towards RWY 07L. However, before the aircraft reached the runway, it took a premature right turn onto TWY A, a taxiway parallel to and situated in between RWY 07L and TWY B. Upon entering TWY A and being aligned with the 07L orientation, it commenced a rolling take-off. This abnormal manoeuvre was detected by the Ground Movements Controller (GMC) on the Advanced Surface Movement Guidance and Control System (A-SMGCS), who promptly alerted the AMC. The AMC immediately instructed FIN070 to stop rolling. The aircraft came to a halt abeam TWY A5, approximately 1400 metres (m) from the western end of TWY A.

Although there was no injury to any person or damage to the aircraft or ground equipment, the aborted take-off resulted in hot brakes. After a period of cooling down of the brakes, the aircraft departed HKIA at 1814. The occurrence was classified as a serious incident as defined under Annex 13 to the Convention on International Civil Aviation. In view of its serious nature, the Chief Investigator of Accident ordered a detailed investigation to identify the causes leading to the incident with a view to preventing recurrence in future.

The following causal factors were identified:

(i) A combination of sudden surge in cockpit workload and the difficulties experienced by both the Captain and the First Officer in stowing the Electronic Flight Bag (EFB) computers at a critical point of taxiing shortly before take-off had distracted their attention from the external environment that resulted in a momentary degradation of

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situation awareness.

(ii) The Standard Operating Procedure (SOP) did not provide a sufficiently robust process for the verification of the departure runway before commencement of the take-off roll.

(iii) The safety defence of having the First Officer and the Relief Pilot to support and monitor the Captain's taxiing was not sufficiently effective as the Captain was the only person in the cockpit trained for ground taxi.

The Investigation Team made six safety recommendations.

Conclusions

3.1.16 Difficulties were experienced by both the Captain and the First Officer in stowing the EFB computers into the respective manual stowage bins while lining up for take-off.

3.1.17 There was no evidence to suggest that the use of the EFB computers in the cockpit had been subject to thorough safety assessment and a sufficiently comprehensive study on the ergonomic aspects of their usage in the cockpit.

3.1.18 Given that the pilots were not familiar with RWY 07L departure, there was an insufficient level of overall situation awareness in the cockpit during the period when the aircraft was turning from TWY B to TWY A, when the EFB computers have already been stowed.

3.1.19 When FIN070 was on TWY A1 before turning onto TWY A, the flight crew made a premature right turn onto TWY A, having mistaken it as RWY 07L.

3.1.20 The combination of a sudden surge in workload and the recommended company procedure of making a "rolling take-off, when possible", allowed little time for the pilots to cross check their position visually before applying take-off power.

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Annex E Incidents and Accidents Reports

FAA Review of ASRs Involving EFBs 2010

Serious Incident A340 Melbourne 2009

Accident (Fatal) B747-200F Halifax Nova Scotia 2004

Serious Incident EMB190 Edmonton 2006

Serious Incident (UK Operator) A330 Montego Bay Oct 2008

Serious Incident A340 Melbourne 2009

Annex F Use of Erroneous Parameters at Take-Off

In 2007, following the investigation of two serious incidents involving tail strikes that had occurred at Paris, Charles de Gaulle Airport (LFPG), a study entitled "*Use of Erroneous Parameters at Take-Off*" was conducted by the Applied Anthropology Laboratory (LAA) at the request of Le Bureau d'Enquêtes et d'Analyses (BEA) and the French Civil Aviation Authority (DGAC).

Various investigation bodies, airlines and manufacturers were consulted in the course of the study because several other accidents, serious incidents and incidents of the same type have occurred around the world during recent years. These generally involved new generation aircraft, being caused by more or less significant errors in entering take-off parameters that were not detected by crews. The errors occurred in various airlines and on various types of large aircraft manufactured by Airbus and Boeing. The most serious event occurred in 2004 and involved the destruction of a B747-200F on take-off at Halifax and the death of all the crew members. Other incidents arising from errors of the same type, but of lesser magnitude, were reported more recently on latest-generation large and medium-sized aircraft such as Embraer 190.

Conclusions of the Study

The research identified the following problematic issues:

- The variety of events shows that the problem of determining and using take-off parameters is independent of the operating airline, aircraft type, equipment and method used;
- Errors relating to take-off data are frequent. They are generally detected by application of airline operating modes or by personal methods such as mental calculation;
- Studied cases reveal that failures correspond to the "calculation of take-off parameters" and "input of speeds into the FMS" functions, but do not correspond to errors in the "weight input into the FMS" function;
- In several cases, the ZFW was entered instead of the Take-off weight into the EFB performance calculator;

- Half of the crews who responded to the survey carried out in one of the participating airlines had experienced errors in parameters or configuration at take-off, some of which involved the weight input into the FMS;

- Pilots' knowledge of the order of magnitude of these parameter values, determined by empirical methods, is the most frequently cited strategy used to avoid significant errors;

- Input of the weight used in parameter calculation, in whatever medium it may be (by ACARS, in a computer, manually), is one of the determining steps in the process of take-off preparation. It is this, by affecting both the thrust and the speeds, that determines take-off safety;

- The real-time availability of final weight information shortly before departure requires the crew to perform a large number of tasks, inputs and parameter displays under strong time pressure;

- Checks on the "take-off parameter calculation" function can be shown to be ineffective because they consist of verifying the input of the value but not the accuracy of the value itself;

- In the same way, the check of data featuring on several media often proves to be ineffective. It is often limited to item by item comparisons. If the item is wrong, the check is correct but inadequate because it doesn't cover overall consistency. In particular, there is no comparison between values for take-off weight given in the final load sheet, on the take-off paper or electronic "card" and in the FMS;

- The reference speed values suggested by some FMS can be easily changed. They do not enable routine detection of prior calculation errors;

- Studied FMS allow insertion of weight and speed values that are inconsistent or outside the operational limits of the aircraft concerned. Some accept an omission to enter speeds without the crew being alerted;

- The weight values manipulated by crews before the flight can appear, depending on the documents or software, under various names or acronyms and in different units and formats for the same data, which makes them too difficult to memorise;

- Time pressure and task interruptions are frequently cited in surveys as common factors contributing to errors. The observations showed that the crews' work load increases as the departure time approaches and that the normal operation actions of the captain were all the more disrupted;

- During the take-off run, the possible decision to reject take-off based on an erroneous V_1 no longer guarantees safety margins;

- On cockpit display screens of the PFD-type (Primary Flight Display), the marker representing V_r is not displayed at low speed. Further, it can be difficult to distinguish it from the marker representing V_1, especially when the two values are similar;

- In several cases, crews perceived abnormal airplane behaviour during take-off. Some took off “normally”, i.e. no abnormal behaviour counter strategy was applied. Others were able to adopt different strategies: stopping take-off, increasing thrust, delayed rotation.

A copy of the report can be found by clicking on this link:

BEA Report Use of Erroneous Parameters at Take-Off

Annex G CAA Mandatory Occurrence Reports

PubRel

Date Printed : 12 June 2013

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These records were retrieved from the UK CAA Mandatory Occurrence Reporting (MOR) system by a member of Safety Data

The MOR system records include information reported to the CAA, information obtained from CAA investigations, and deductions by CAA staff based on the available information. The authenticity of the contents or the absence of errors and omissions cannot be guaranteed. Records in this system commenced on 1 January 1976 coincident with the introduction of Mandatory Occurrence Reporting in the UK, but occurrences reported voluntarily are also included, and no distinction is made between them.

Note: Any data provided from these records are made available on the understanding that they are only to be used for purposes of flight safety and must not be used for other purposes.

SUBJECT: EFB/LPC Reports
PERIOD : All

A/C Type :	A319	**Occurrence Number :**	**200605574**
Flight Phase :	Take Off	**Occurrence Date :**	15 Jun 2006
Classification :	Occurrences	**Location :**	Bristol International
Events :	A/c Loading Problem Flight Crew Occurrence	**Location Info :**	

Pretitle :
Incorrect weight and balance figures led to an A319 taking off 900kg over the expected take off weight.

Precis :
The loading form had an error of 900kgs in the baggage weight figures. The P2 entered the incorrect figures into the LPC weight and balance module. The P1 checked the loading form and noted the odd passenger number versus bag weight ratio but did not delete the error. Possible causal factors were that the P1 was talking to the engineer about an FMGC problem as departure time approached and it was the P1's fourth early sector.

A/C Type :	B747	**Occurrence Number :**	**200700913**
Flight Phase :	Cruise	**Occurrence Date :**	29 Jan 2007
Classification :	Occurrences	**Location :**	Cairo
Events :	A/c Equipment / System Malfunction Pressurisation Failure Electronic Interference	**Location Info :**	

Pretitle :
Uncommanded cabin pressure change, possibly associated with use of laptop computer. Unable to determine cause. The wireless application has been since disabled as a precautionary measure.

Precis :
In the cruise at FL350, the Captain and flight engineer were working with the Electronic Flight Bag (EFB) computer (laptop) at the flight engineer's desk while completing the electronic voyage report. Suddenly an unscheduled cabin pressure change was experienced, with the cabin climbing at 1000-1500fpm and the rate light illuminating. Checklist actioned and pressure control regained. It was considered likely that the pressure change had been caused by use of the laptop. Pressurisation system was checked as was the on board laptop. However it was not confirmed if the laptops wireless application was enabled at the time of the incident. The wireless application has since been disabled as a precautionary measure. No further occurrences.

A/C Type :	A319	**Occurrence Number :**	**200810576**
Flight Phase :	Not Applicable	**Occurrence Date :**	08 Sep 2008
Classification :	Occurrences	**Location :**	Nice
Events :	Flight Crew Occurrence	**Location Info :**	

Pretitle :
Landing distance for R/W04L incorrect in the LPC landing module and Jeppesen plate W-9A. Distance value given as 2720m should be 2570m as stated on plate 10-9.

Precis :
Reporter believes that the stopway distance has been included in the landing distance.

A/C Type :	A320	**Occurrence Number :**	**200902041**
Flight Phase :	Parked	**Occurrence Date :**	04 Mar 2009
Classification :	Occurrences	**Location :**	Manchester (MCT)
Events :	A/c Equipment / System Failure Smoke / Fumes (not engine)	**Location Info :**	

Pretitle :
Arcing and flames from failed power supply lead for Electronic Flight Bag (EFB) laptop computer installed on flight deck. Hazard.

Precis :
On arrival at aircraft it was unmanned with doors closed and with external power connected, supplying AC power (allegedly with no supervision). On entering flight deck P2 moved his laptop computer from P2 seat to side console and approx 30 seconds later smelled burning and observed sparks, a bright white glow and smoke emanating from charging lead connected to his laptop. Lead immediately disconnected from laptop and power jack socket in laptop tray. All leads were already connected prior to crew arrival. Potential flight deck fire risk when aircraft was unattended is considered high. Power lead sent for investigation. Reporter suggests inspection of all 'Kensington' type power supplies in use on fleet aircraft.
Exposed wires resulting from chaffing of the power adapter cable, where the cable meets the laptop connector, caused the event. Power adapter cable changed and a fleet check of all power adapters of this type carried out, with no other findings. An instruction was put on all the operators fleet of aircraft of the same type, that no unattended charging of LPCs was allowed. This was followed up with a NTC. A new power adapter cable is being manufactured with better shielding and a 90deg laptop connector. An additional task has been added to the AMP.

A/C Type :	A319	**Occurrence Number :**	**200906169**
Flight Phase :	Cruise	**Occurrence Date :**	14 Jun 2009

Classification :	Occurrences	**Location :**	En Route
Events :	A/c Equipment / System Failure	**Location Info :**	

Pretitle :
Captain's LPC battery went flat despite being plugged into charging point. Power outlets found to have tripped off.

Precis :

A/C Type :	B737	**Occurrence Number :**	**200907016**
Flight Phase :	Parked	**Occurrence Date :**	07 Jul 2009
Classification :	Occurrences	**Location :**	Cardiff (CDF)
Events :	A/c Equipment (non-AW) Failure	**Location Info :**	

Pretitle :
Three different sets of take-off performance calculations.

Precis :
Despite synchronised laptops prior to flight. When calculating take-off performance using C-TOP, the results differed significantly on both pilot laptops. Performance was checked with GOC dispatcher who then came up with yet different calculations. The GOC dispatcher advised that the GOC performance calculator is generic and does not allow for anything other than full-thrust departures. Being left with three different sets of performance calculations, the crew eventually used the only set that could be cross-referenced.
The root cause was found to be a corrupt program on the Captains computer, which the SOPs identified. All crew action was correct, and the information provided to the crew by GOC analysis was correct. Due to the crew not being aware of the nature of the GOC analysis, the operator has implemented a 'Notice to Crews' and will be amending the company manuals clearly identifying the generic nature of GOC analysis, and that flight crews will be required to have a copy of the GOC analysis either by email, fax or ACARS.

A/C Type :	A319	**Occurrence Number :**	**200908318**
Flight Phase :	Parked	**Occurrence Date :**	07 Aug 2009
Classification :	Occurrences	**Location :**	Luton (LUT)
Events :	Flight Crew Occurrence Miscellaneous Non-AD Occurrence A/c Loading Problem	**Location Info :**	

Pretitle :
Conflicting MTOW information between FOVE/FMGC/OFP and Company Operations Department.

Precis :
Whilst entering performance details into FOVE (Flight Operations Versatile Environment) on LPC (Less Paper Cockpit) laptop, crew realised that aircraft would be approx 700kg above MTOW on a tanking sector. Figures checked for errors and when none found, refuelling was stopped to prevent overloading. It was then realised that OFP (Operational Flight Plan) had a MTOW of 66000kg, whilst FOVE was 64300kg and FMGC was 64.3 tonnes. FOVE weight was used, as it was the most limiting. A new loadsheet was required and when the new data was entered into FOVE the aircraft underload had changed by nearly 2000kg - FOVE MTOW had changed from 64.3 to 66 tonnes. Crew confirm that laptop had not been changed or altered in any way except for insertion of new loadsheet data.

A/C Type :	A319	**Occurrence Number :**	**201002728**
Flight Phase :	Take Off	**Occurrence Date :**	13 Mar 2010
Classification :	Occurrences	**Location :**	Rome Ciampino
Events :	Miscellaneous Non-AD Occurrence Flight Crew Occurrence	**Location Info :**	

Pretitle :
Conflicting information contained within LPC (Less Paper Cockpit).

Precis :
Normal acceleration during take-off, however, TOGA had to be selected due to the stop end of R/W coming close. When figures put into LPC, it was noticed that the MTOW was limited to 63.4 tonnes. Upon checking the LPC during the cruise, calculations had changed to that of another airport.

A/C Type :	B737	**Occurrence Number :**	**201005502**
Flight Phase :	Parked	**Occurrence Date :**	13 Jun 2010
Classification :	Occurrences	**Location :**	Manchester (MCT)
Events :	Flight Crew Occurrence	**Location Info :**	

Pretitle :
CTOP (Computerised Take-Off Performance) discrepancy due to incorrect programme source code.

Precis :
During CTOP calculation prior to flight a difference was observed with CTOP v42 and CTOP v41. When take-off performance was calculated crew were presented with two different V1 speeds. On further investigation it appeared that v42 did not change V1 for wet or dry performance. Lower V1 was selected and v41 used for take-off performance. Subsequent investigation revealed that when CTOP version 9.1 was released on 7 Jun 2010 an error was made in programme source code that caused programme to calculate dry runway performance when wet runway was selected. Updated version 9.2 has now been released to correct error and an Operations Notice had been published to advise crews not to use previous version 9.1 for wet take-off performance calculations. Quality checking processes to be assessed.

A/C Type :	B767	**Occurrence Number :**	**201103809**
Flight Phase :	Parked	**Occurrence Date :**	13 Apr 2011
Classification :	Occurrences	**Location :**	London-Gatwick - LGW
Events :	A/c Equipment / System Malfunction Smoke	**Location Info :**	

Pretitle :
Following shutdown after arrival, First Officer's laptop observed to be emitting smoke from external and monitor output ports. Battery removed and smoke ceased.

Precis :
External and monitor output sockets noted to be "slightly deformed".
The laptop had been placed on the floor on its side with the external and monitor output sockets in contact with the floor. This had possibly caused the short as the sockets appeared slightly deformed, likely from day to day wear and tear. Assessment by Flight Support Unit carried out.

A/C Type :	B767	**Occurrence Number :**	**201110954**
Flight Phase :	Cruise	**Occurrence Date :**	13 Sep 2011
Classification :	Occurrences	**Location :**	En Route
Events :	Smoke A/c Equipment / System Malfunction	**Location Info :**	

Pretitle :
Smoke from Captain's flight crew laptop 5mins after being switched on. Battery removed and smoke ceased.

Precis :
The reporter notes the laptop was several years old and was damaged following return from an upgrade.

A/C Type :	A321	**Occurrence Number :**	**201205636**
Flight Phase :	Parked	**Occurrence Date :**	24 May 2012
Classification :	Occurrences	**Location :**	Zakinthos
Events :	A/c Technical Occurrence	**Location Info :**	

Pretitle :
No access to MEL on electronic flight library.

Precis :
Second occasion of this problem, possible bug in the latest issue of software.

Number of Records : 14

Annex H Definitions

Automatic Dependent Surveillance Broadcast

ADS-B is a Surveillance technique that relies on aircraft broadcasting their identity, position and other information derived from on board systems (GNSS etc.). This signal can be captured for surveillance purposes on the ground (ADS-B Out) or on board other aircraft (ADS-B In). The latter will enable airborne traffic situational awareness (ATSAW), spacing, separation and self-separation applications.

ADS-B is automatic because no external stimulus is required; it is dependent because it relies on on-board systems to provide surveillance information to other parties. Finally, the data is broadcast, the originating source has no knowledge of who receives the data and there is no interrogation or two-way contract.

ADS-B is a key enabler of the future ATM Network, contributing to the achievement of the Single European Sky (SES) performance objectives, including safety, capacity, efficiency and environmental sustainability. Airborne ADS-B systems will be available as enablers of the new separation modes. These airborne applications will require changes in the avionics to process and display the air situation picture to the pilot.

The introduction of ADS-B in the Surveillance infrastructure provides important features which can be exploited by the ATM Network:

- Full “Network-wide” Surveillance coverage;
- Surveillance “everywhere”, i.e. no gaps from gate-to-gate;
- Air-to-air Surveillance possible, i.e. traffic situational awareness picture available on board;
- The aircraft is integral part of the Network;
- Surveillance data provided directly from on-board systems;
- Increased airspace capacity
- Reduced cost of the Surveillance infrastructure (ADS-B is cheaper than radar);
- More efficient flight profiles (in areas where previously surveillance was not cost-effective);
- Fuel savings etc;
- Environmental sustainability (CO2 reduction);
- Global Interoperability.

The Single European Sky Surveillance Performance and Interoperability Implementing Rule (SPI IR) was approved in July 2011 and will be published in the Official Journal of the European Union in the course of 2011. The SPI IR will require all aircraft operating IFR/GAT in Europe will have to be compliant with Mode S Elementary Surveillance, whilst aircraft with maximum Take-Off Mass greater than 5700kg or maximum cruising True Air Speed greater than 250kts will have to be compliant with Mode S Enhanced Surveillance and “ADS-B out”. The mandate dates are January 2015 for forward fit and December 2017 for retrofit, with further provisions for State aircraft.

Aircraft Equipment

The “ADS-B Out” capability on board is enabled by transponders interfaced with the relevant avionics systems (such as GNSS, pressure altimeters etc.). The “ADS-B In” capability requires a receiver, a processing system (traffic computer) and an HMI unit (often called Cockpit Display of Traffic Information - CDTI). The “ADS-B in” system could be integrated in an EFB.

The operational use of ADS-B requires certification and operational approval by the regulatory authorities.

Airworthiness Approval

Airworthiness is a term used to indicate when an aircraft conforms to its approved design and is in a condition for safe operation. This is indicated by the issue of an Airworthiness Certificate.

An "Airworthiness Certificate" is issued to an aeroplane that is registered in one State and was found to conform to its approved design, typically detailed in the Type Certificate Data Sheet (TCDS), and be in a condition for safe operation, it does not guarantee the aeroplane has the operational and emergency equipment installed to carry out specific operations. It is illegal to fly an aeroplane on an international flight without first obtaining an airworthiness certificate from the State of Registry.

A TC is awarded by the State of Design to aeroplane designers after they have shown that the particular design of a civil aeroplane conforms to the States design standard. The TC normally includes the type design, the operating limitations, the Type Certificate Data Sheet, the applicable regulations, and other conditions or limitations prescribed by the NAA.

A modification to an aeroplane is typically detailed in a Supplemental Type Certificate (STC). This document is issued by the State of Registry of the Aeroplane. The STC defines the product design change and states how the modification affects the existing type design.